Chapter 4

PATTERN UNDERSTANDING

The curve described by the earth as it turns is a spiral, and the pattern of its moving about the sun... The solar system itself being part of a spiral galaxy also describes a spiral in its movement... Even for the case of circular movement, when one adds in the passage of time, the total path is a spiral... The myriad things are constantly moving in a spiral pattern... and we live within that spiral movement.

(Hiroshi Nakamura, from *Spirulina: Food for a Hungry World*, University of the Trees Press, P.O. Box 66, Boulder, California 95006, USA.)

The patterns and forms of a tree are found in many natural and evolved structures; an explosion, event, erosion sequence, idea, germination, or rupture at an edge or interface of two systems or media (here, earth and atmosphere) may generate the tree form in time and space. Many threads spiral together at the point of deformation of the surface and again disperse. The tree form may be used as a general teaching model for geography, ecology, and evolution; it portrays the movement of energy and particles in time and space. Foetus and placenta; vertebrae and bones; vortices; mushrooms and trees; the internal organs of man; the phenomena of volcanic and atom bomb explosions; erosion patterns of waves, rivers, and glaciers; communication nets; industrial location nets; migration; genealogy; and perhaps the universe itself are of the general tree form portrayed.

Simple or multiple pathways describe yin-yang, swastika, infinity, and mandala symbols. A torus of contained forces evolves with the energies of the pattern, like the doughnut of smoke that encircles the pillar of the atomic explosion.

(Bill Mollison, *Permaculture One*, 1978.)

Everything the Power of the World does is done in a circle... The wind, in its greatest power, whirls... The life of a man is a circle from childhood to childhood, and so is everything where power moves. Our teepees were round like the nests of birds, and these were always set in a circle, the nation's hoop, a nest of many nests....

(Black Elk.)

4.1 INTRODUCTION

It is with some trepidation that I attempt a treatise on patterns. Nevertheless, it must be attempted, for in patterning lies much of the ground skill and the future of design. Patterns are forms most people understand and remember. They are as memorable and repeatable as song, and of the same nature. Patterns are all about us: waves, sand dunes, volcanic landscapes, trees, blocks of buildings, even animal behaviour. If we are to reach an understanding of the basic, underlying patterns of natural phenomena, we will have evolved a powerful tool for design, and found a linking science applicable to many disciplines. For the final act of the designer, once components have been assembled, is to make a sensible pattern assembly of the whole. Appropriate patterning in the design process can assist the achievement of a sustainable yield from flows, growth forms, and timing or information flux.

Patterning is the way we frame our designs, the template into which we fit the information, entities, and objects assembled from observation, map overlays, the analytic divination of connections, and the selection of specific materials and technologies. It is this patterning that permits our elements to flow and function in beneficial relationships. The pattern *is* design, and design is the subject of permaculture.

Beyond the rigour of the simple Euclidean regularities beloved of technologists and architects, there remains most (or all) of nature. Nature imperfectly round, never flat or square, linear only for infinitesimal distances, and stubbornly abnormal. Nature flowing, crawling, flying, weeping, and in apparent disarray. Nature beyond precise measurement, and comprehensible only as sensation and system.

Nothing we can observe is regular, partly because we ourselves are imperfect observers. We tell fortunes (or lose them) on the writhing of entrails or cathode ray graphics, on the scatters of dice or bones, or on arrays of measures. Are the readings of tea leaves any less reliable than the projections of pollsters? Regular things are those few that are mechanical or shaped (temporarily) by our own restricted world view; they soon become irregular as time erodes them. Truth, like the world, changes in response to information.

There are at least these worthwhile tasks to attempt:

1. A MORE GENERAL PATTERN UNDERSTANDING, both as attempts at forming more general pattern models, and as examples of natural phenomena that demonstrate such models.

2. A LINKING DISCIPLINE that equally applies to geography, geology, music, art, astronomy, particle physics, economics, physiology, and technology. This linking discipline would apply to conscious design itself and to the information flow and transfer processes that underlie all our disciplines. Such a unifying concept has great relevance to education, at every level from primary to post-graduate disciplines.

3. GUIDES TO PATTERN APPLICATION: some examples of how applied patterning achieves our desired ends in everyday life, where rote learning, linear thinking, or Euclidean geometry have all failed to aid us in formulating sustainable settle-ments. It is in the application of harmonic patterns that we demonstrate our comprehension of the meaning of nature and life.

There have been many books on the subject of symbols, patterns, growth, form, deformation, and symmetry. The authors often abandon the exercise short of devising general models, or just as a satisfactory mathematical solution is evolved for one or more patterns, and almost always before attempting to create applied illustrations of how their efforts assist us in practical life affairs. Some are merely content to list examples, or to make catalogues of phenomena. Others pretend that meanings lie in pattern or number alone—that patterns are symbols of arcane knowledge, and they assert that only an unquestioned belief unlocks their powers.

The simple pattern models figured herein are intended to be a useful adjunct to designers and educators. They also illustrate how we can portray our thinking about life, landscapes, and the communality that is nature. Learning a master pattern is very like learning a principle; it may be applicable over a wide range of phenomena, some complex and some simple. As an abstraction, it assists us to gain meaning from life and landscape and to comprehend allied phenomena.

One can spend endless hours seeking further scientific, mystical, or topological insights into pattern. The process is addictive, and I am as unwilling to abandon this chapter as I was to start it, but I trust that others, better equipped, will expand and further explain the basic concepts. I believe that it is in sophisticated pattern application that the future of design lies, and where many solutions to intractable problems may be found.

We have a good grasp on the behaviours of pattern in natural phenomena if we can explain the SHAPES of things (in terms of their general pattern outlines); the networks and BRANCHING of tributaries (gathering flows) and distributaries (dispersal flows); the PULSING and flow regulation within organisms or the elements of wind, water, and magma; and illuminate how SCATTERED PHENOMENA arise.

Further, if WAVE phenomena and STREAMLINES are contained within our pattern analysis, as real waves or as time pulses, these and their refraction and interference patterns form another set of pattern generators, responsible for coasts, clouds, winds, and turbulent or streamlined flow. And, if we can show how the pattern outlines of landscapes, skeletal parts, or flow phenomena fit together as MATRICES (interlocking sets), or arise from such matrices (e.g. whirlwinds from thermal cells), then we can generate whole landscape systems or complete organisms from a mosaic of such patterns.

In nature, events are ordered or spaced in discrete units. There are smaller and larger orders of events, and if we arrange like forms in their *orders*, we will find clusters of measures at certain sizes, volumes, lengths, or other dimensions. This is true for river branches, social castes, settlement size, marsupials of the same form, and arrays of dunes, planets, or galaxies.

In the following pages, I will try to include all this and to derive it from the basis of a single "simple" model (**Figure 4.1**), which, understood in all its parts, has each of these phenomena, and a great many more subtle inferences, within it. Not all, or even many, of these shapes, symbols, symmetries, scatters, or forms will be individually described or figured here, but the basic pattern parts will be briefly described and related to each other. The basic model itself is derived from a stylised tree form.

We should not confuse the comprehension of FORM with the knowledge of SUBSTANCE—"the map is not the territory"—but an understanding of form gives us a better comprehension of function, and suggests appropriate strategies for design.

4.2

A GENERAL PATTERN MODEL OF EVENTS

When we look about us in the world, we see the hills, rivers, trees, clouds, animals, and landforms generally as a set of shapes, apparently unrelated to each other, at least as far as a common underlying pattern is concerned. What *do* we see? We can list some of the visible forms as follows:

- WAVES on water and "frozen" as ripples in dunes and sandstones, or fossilised quartzites and slates.
- STREAMLINES, as foam strips on water, and in streams themselves.
- CLOUD FORMS in travertine (porous calcite from hot springs), tree crowns, and "puffy" clouds or as cloud streams.
- SPIRALS in galaxies, sunflowers, the global circulation of air, whirlpools, and chains of islands in arcs.
- LOBES, as at the edge of reefs, in lichens, and fringing the borders of salt pans.
- BRANCHES, in trees and streams converging or diverging; explosive shatter zones.
- SCATTERS of algae, tree clumps in swamps, islands, and lichens on rocks.
- NETS as cracks in mud, honeycomb, inside bird bones, in the columns of basalt (as viewed from above), and cells of rising and falling air on deserts.

The NETS or cracks in mud and cooling lava are shrinkage patterns caused not by flow or growth, but by the *lateral tension* of drying or cooling, as are many patterns in iceflows and the cracked pattern of pottery, or the cracks in bark on trees. Thermal wind cells arise at the confluence of large heat cells on desert floors, forming a net pattern if viewed from above or below.

In all of these categories, I hope to show that one master pattern is applicable, and that even the bodies of animals are made up of bones, organs, and muscles of one or more of the forms above. I will link these phenomena—generated by growth and flow— into a single model form. That form is a stylised tree (**Figure 4.1**). Around the central tree form of this model are arranged various cross-sections, plans, longitudinal sections, and streamline paths, all derived from real sections, paths, or projections of the tree.

The evolution of such a form from an initial point in space-time, I call an EVENT. Such events can be abstract or palpable. They have in common an origin (O), a phase of growth (T1–T6: an expression of their energy potential), decay, and dissolution into other events of a like or unlike form. The event of a tree is at least three-dimensional, and must be thought of as extending into and out of a plane (P). However, many similar events such as migration patterns or glaciation can be as well portrayed (as they are seen in aerial photographs) as two-dimensional.

The curvilinear STREAMLINES (S1–S9), are seen to curve or spiral through the Origin, just as (in fact) the phloem (storage cells) and xylem (sapbearing cells) spiral through the X–X' axis, or earth surface plane (P), of a real tree. Not so easy to portray is the fact that the xylem is *external* to the stems and *internal* to the roots, and the phloem the reverse. At a zone in the plane (P), therefore, these cells INTERWEAVE or cross over as they spiral out of or into the media.

This deceptively simple "apple core" or tree shape, spiralling out of the plane (P) is a slow-moving vortex such as we see in tornadoes and whirlpools. Traffic through the streamlines is *in both directions*. In trees, sugars and photosynthetic products travel from crown to root margin, and water and minerals from roots to crown. Thus, each margin of our pattern is both collecting and distributing materials from different media. The tree trades both ways with elements of the media, and there is an active water and gaseous exchange with the media (M1, M2). Two-way trade is the normality of plants, organs, and natural forms.

As we know, a crosscut of a tree stem, the basis of the study of dendrochronology, reveals a target pattern of expanding growth (by which the tree adds bulk annually) and from which we can discover much about past occurrences of drought, seasonal changes, atmospheric compositon, fire, and wind (**Figure 4.1–F**).

Screw palms (*Pandanus* spp.) of the tropics develop *ascending* stem spirals, very reminiscent of fan turbine blades, and sunflowers create open seed spirals (in two directions), so common in many whorled plants. The stem itself forces open an ever-expanding flow through the X–Y plane between the media, allowing more material to pass through as time accumulates. The event expands the initial rupture of the surface between the media, allowing greater flow to take place, and this too is recorded in the target pattern of the stem, at the point of germination of the event (O).

4.3
MATRICES AND THE STRATEGIES OF COMPACTING AND COMPLEXING COMPONENTS

A set of intersecting sine waves developed over a regular square or hexagonal matrix will set up a surface composed of our core model shapes. It doesn't matter if we see the sine waves as static or flowing, the core model will still maintain its shape, and flow in the system does not necessarily deform the pattern. Such a pattern matrix (**Figure 4.2**) shows that our models **tessellate** (from the Latin *tesserae*, meaning tiles) to create whole surfaces. If landscapes are, in fact, a set of such models, they must be able to tessellate.

Convection cells on deserts arise from a roughly hexagonal matrix of air cells 1–5 km across, and matrices also underlie the spacing of trees in forests.

Glacial landscapes show whole series of such patterns, as do regular river headwaters. We could equally well have created a matrix by adding in samples of our core pattern as we add tiles to a floor. Thus we see the Euclidean concept of points and lines underlies our curvilinear forms. Even irregular models (**Figure 4.3**) tessellate. Such tessellae are centred on nets or regular grids.

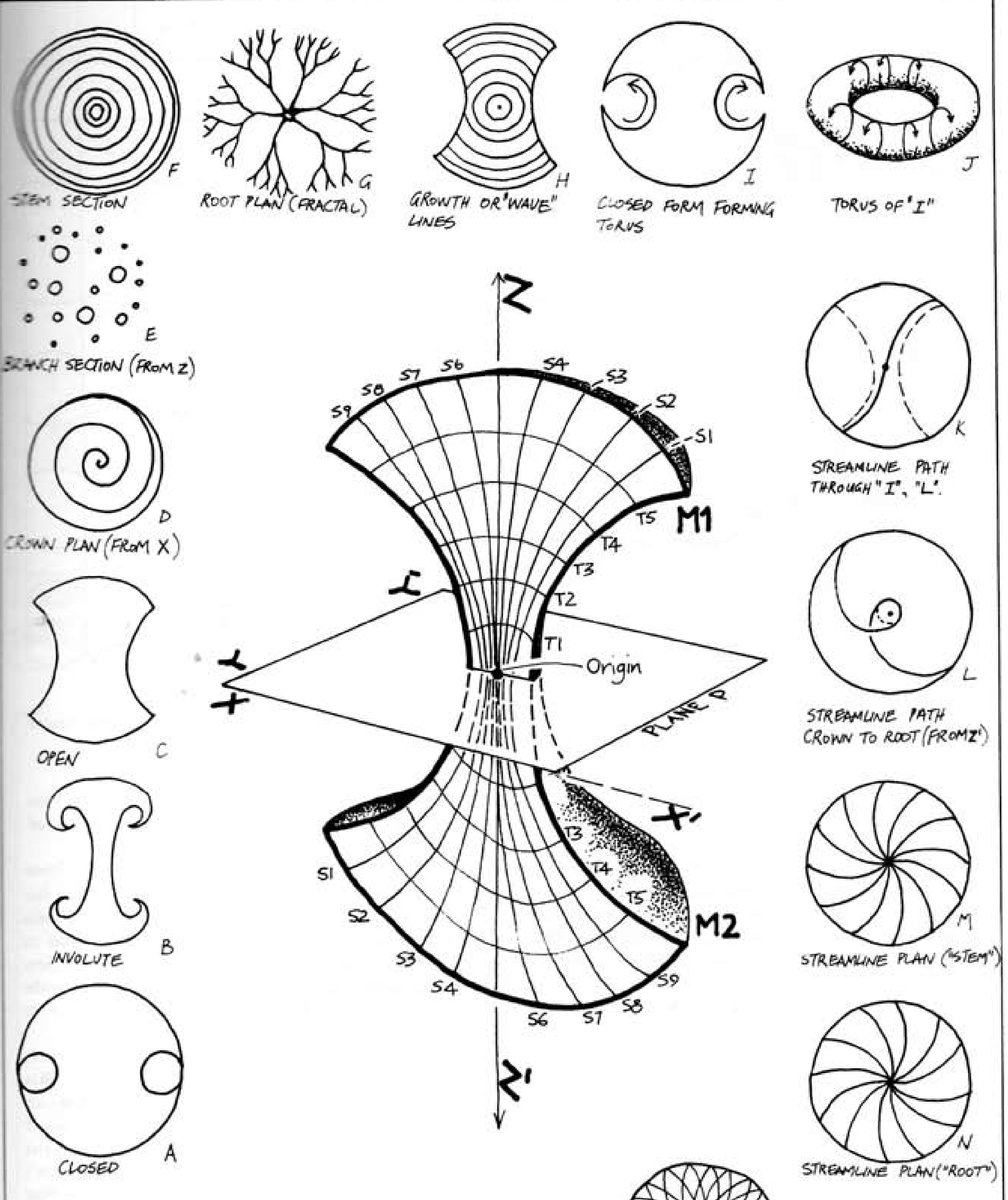


FIGURE 4.1
GENERAL CORE MODEL
The general core model spirals out of a plane P (between two media M1 and M2). Several sections are given to show some of the model forms from projections and sections of a single event (here, a " tree"). In deserts,Such phenomena as trees have a basic matrix or spacing, as do whirlwinds in the desert (at the junction of hexagonal cells), and events on the surface of the sun.

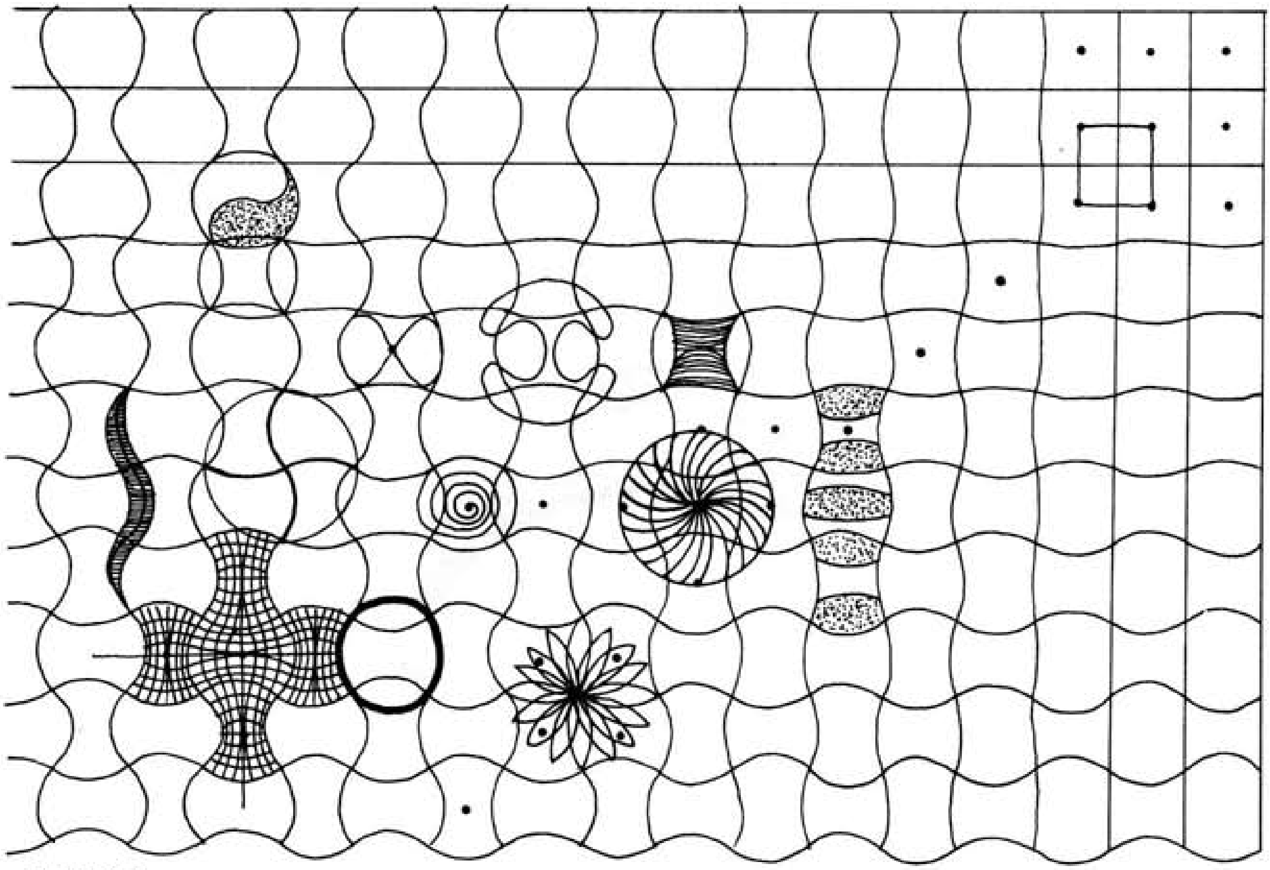


FIGURE 4. 2
PATTERN MATRIX OF TESSELATED PATTERNS.
Underlying many natural distributions (e.g. trees in a desert, heat or convection cells) and forming many patterns (such as honeycomb and cracks in mud) are matrices or grids based on approximate squares, hexagons, or intersecting sine waves.

The "growth lines" (T-series) of our models are, in effect, a series of smaller and smaller forms nested within the larger boundaries, as is the case with target patterns or tree cross-sections. The process is termed **annidation** (Latin *nidus*, a nest) and is used in practice to compactly store bowls or glasses, one within the other; it then becomes a strategy for fitting-in like components of the same or different size in a compact way.

If we *superimpose* two spirals of the opposite sense (spirals twisting in the opposite way), we develop the petal patterns of flowers and the whorls of leaves so common in vegetation, well illustrated by the seed patterns of sunflowers. The effect is also reproduced by simple reflection of such curves.

Thus we see that tessellation, annidation, or superimposition gives us a strategy set for developing complex and compact entities, or for analysing complex landscapes. As Yeomans(5) points out, ridges and valleys in landscape are identical reflections. If we model a landscape and pour plaster of Paris on the model, we reproduce the landscape in a reversed plaster model, but now the ridges are valleys.

Further, a set of our models invading into or generating from a portion of the landscape produce EXPANSION and CONTRACTION forms **(Figure 4.4)** typical of the edges of inland dunes and salt pans. This crenellated (wavy) edge produces **edge harmonics** of great relevance to design.

The study of matrices reveals that the T (time) lines are **ogives** of a tessellated model and develop from the "S" (stream) lines of the next model adjoining. We then come to understand something of the co-definitions in our core model, and its inter-dependent properties. Sets of such models and their marginal crenellations provide a complex interface in natural systems, often rich in production potential.

The earth itself is "a great tennis ball" (*New Scientist*, 21 April '77) formed of two core model forms. This earth pattern **(Figure 4.5)** of two nested core models can be re-assembled into a single continent and one sea if the present globe is shrunk to 80% of its present diameter. My old geology professor, Warren ("Sam") Carey may have been justified in his 1956 assertion that the earth was originally that much smaller. When re-assembled in this way, the globe shows an origin ("O" of our model) over each pole; the north polar origin is that of the seas, the antarctic origin that of the continents. At that time in earth history, all life forms were native to a single continent and all fish swam in one sea.

The pattern has been shattered by a total expansion of

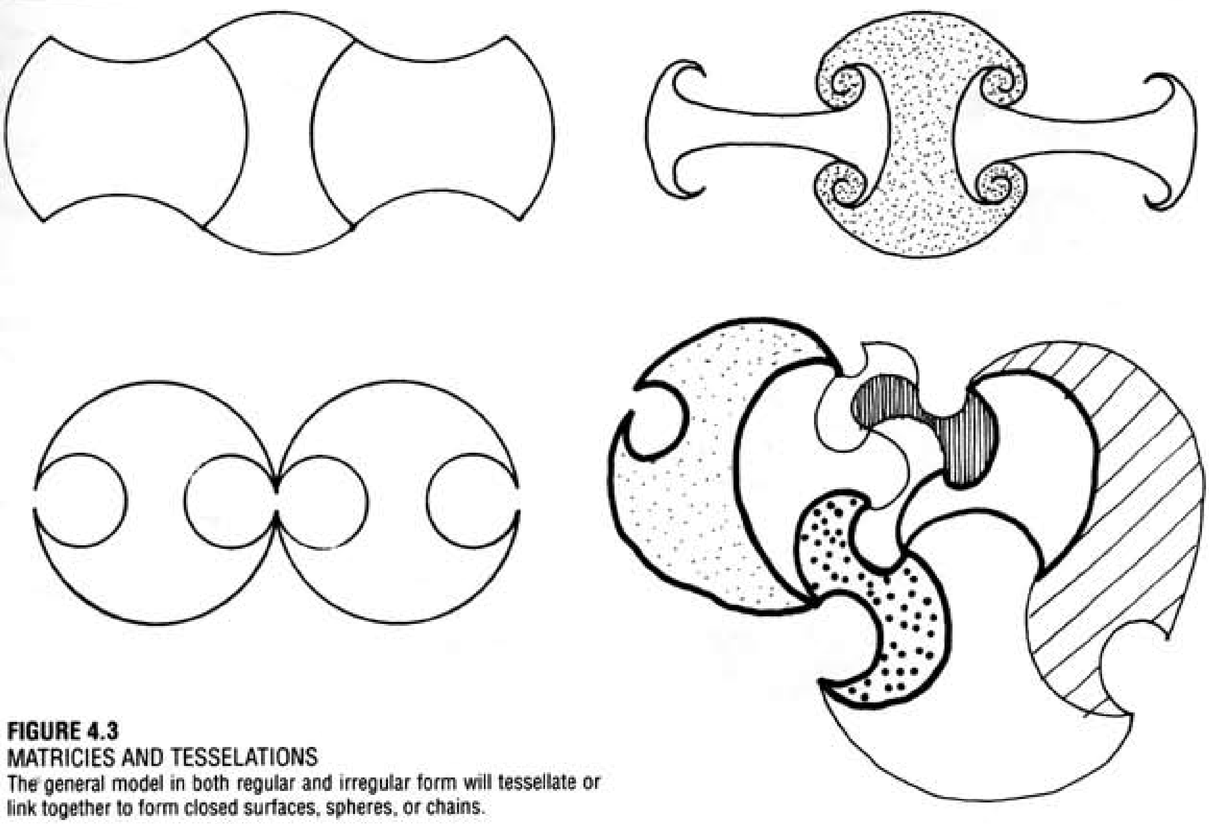


FIGURE 4.3
MATRICIES AND TESSELATIONS
The general model in both regular and irregular form will tessellate or link together to form closed surfaces, spheres, or chains.

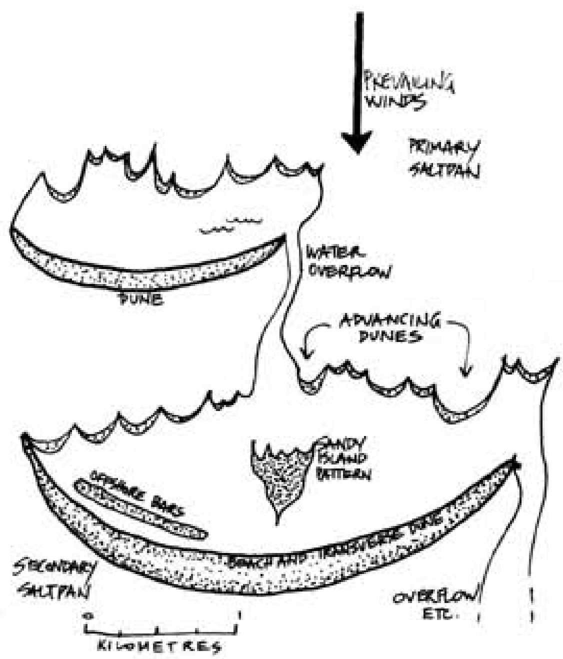


FIGURE 4.4
PATTERNS IN DESERTS
Repetitive patterning due to wind, sand, and rare heavy rains, is typical of deserts; this series of lunulate lagoons occurs in South Australia. Longitudinal dunes become crescentic transverse dunes due to water action.

the globe or by the spreading of oceanic plates cracking the continents apart rather like the net patterns on a mud patch, and isolating species for their present endemic development. The whole story is being slowly assembled by generations of biologists (Wallace, Darwin), geologists, and technicians analysing data from satellite surveys of the globe.

The original pattern shattered, continents now drift, collide, and form their own life pattern by isolation, recombination, and the slow migration of natural processes. The process also illustrates how irregularities may arise on an expansion of a previously regular matrix of forms; tension caused by expanding phenomena shatters the smooth flow of primary global events. At the end of a certain energy sequence, old patterns shatter or erode to make way for new patterns and succeeding forms of energy, as a decaying tree gives life to fungi and to other trees.

4.4
PROPERTIES OF MEDIA

Media, as a result of their chemistry, physical properties, or abstract characteristics, can be identified by us because they *differ* from each other. We distinguish not only air, water, earth, and stone but also hot, cold, salty, acid, and even some areas of knowledge as having different properties or validity. Every such

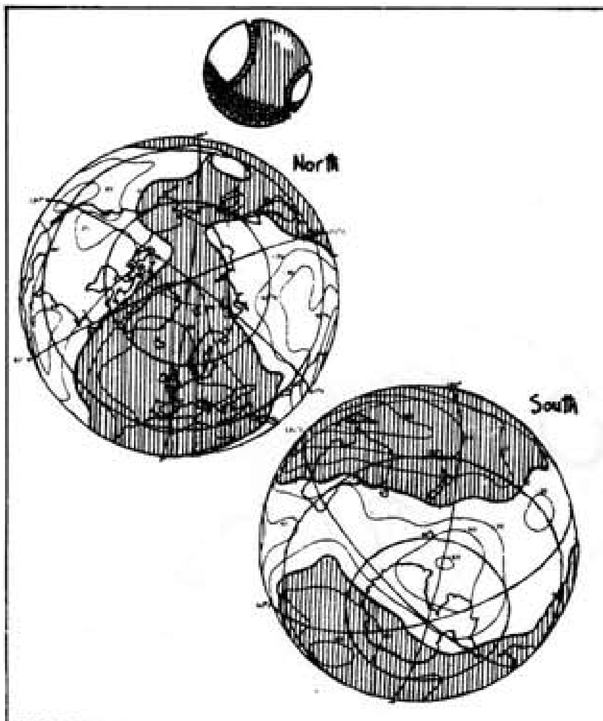


FIGURE 4.5
"THE GREAT TENNIS BALL OF EARTH"
Only two core models make up the geoid. Each is detectably higher than, or lower than, the other. Origins lie near the poles, and when the continents are re-assembled we have one great continent and one great sea.

difference has a more or less well defined BOUNDARY CONDITION, surface, or interface to other media or systems. Permaculture itself acts as a translator between many disciplines, and brings together information from several areas. It can be described as a framework or pattern into which many forms of knowledge are fitted in relation to each other. Permaculture is a synthesis of different disciplines.

Any such boundary is at times between, at times within, media, and (as in the case of the earth/air surface) these boundaries, surfaces, or perceptible differences present a place for things to happen, for *events to locate*. Thus, boundaries present an opportunity for us to place a translatory element in a design, or to deform the surface for specific flow or translation to occur.

If the media are in gaseous or liquid form, or composed of mobile particles like a crowd of people, swarm of flies, water, or dust clouds, then the media are themselves capable of flow and deformation.

In nature, many such media and boundaries can be distinguished. As one example, a pond (with part of its margin) is shown in **Figure 4.6**.

Although differently named (or not named at all), all these surfaces, edges, and boundaries separate different media, ecological assemblies, physical states, or flow conditions. Every boundary has a unique behaviour and a translation potential. Living translators (trees, fish, molluscs, water striders) live at each and every boundary. We can see that the establishment of complex boundary conditions is another primary strategy for generating complex life assemblies and energy translators.

"Most biologists," (says Vogel, 1981) "seem to have heard of the boundary layer, but they have a fuzzy notion that it is a discrete region, rather than the discrete notion that it is a fuzzy region."

Boundary/Edge Design Strategy
The creation of complex boundary conditions is a basic design strategy for creating spatial and temporal niches.

4.5
BOUNDARY CONDITIONS

Boundaries are commonplace in nature. Media are variously liquid, gaseous, or solid, in various states of flow or movement. They have very different inherent characteristics, such as relatively hotter, more acid, rough, harder, more absorbent, less perforated, darker, and so on. Even in abstract terms, society divides itself in terms of sex, age, culture, language, belief, disciplines, and colour (just to enumerate a few perceived differences).

In this confusion of definitions, social and physical, we can make one statement with certainty. People discriminate (in its true meaning, of *detecting a difference*) between a great many media or systems, and therefore recognise boundary conditions or "sorts", enabling them to define like and unlike materials or groups in terms of a large number of specific criteria.

Differences, whether in nature or society, set up a potential STRESS CONDITION. This may demonstrate itself as media boundary disturbances, friction, shear, or turbulence caused by movement, sometimes violent chemical reactions, powerful diffusion forces, or social disruption. Seldom do two different systems come in contact without a boundary reaction of one sort or another, as quiet as rust, as noisy as political debate, or as lethal as war.

If we concentrate our attention on the boundary condition, there are, crudely, two common or possible motions or particle flows—ALONG or ACROSS boundaries. In *longitudinal* flows (shear lines) between media, deflections and turbulence may be caused by local friction or the more cosmic Coriolus (spin) force. In *crossing* a boundary between media, the surfaces themselves may resist invaders (chemical or social); or various nets, sieves, or criteria may have to be by-passed by a potential invader.

However, these boundaries are, in nature, often very rich places for organisms to locate, for at least these reasons:

- Particles may naturally accumulate or deposit there (the boundary itself acts as a net or blockade).
- Special or unique niches are available in space or time within the boundary area itself.

• The resources of the two (or more) media systems are available at the boundary or nearby.

Special physical, social, or chemical conditions exist on the boundary, because of the reaction between the adjacent media. As all boundary conditions have some fuzzy depth, they constitute a third media (the media of the boundary zone itself).

This last statement is especially true of diffusive or flowing media, and of turbulent effects. Turbulence, in effect, creates a mix of the two or more media which may itself form another recognisable medium (e.g. foam on water, an emulsion of oil and water).

In our world of constant events, especially in the living world, more events occur at boundaries than occur elsewhere, because of these special conditions or differences. It is common to find that there are more different types of living species at any such boundary or edge than there are within the adjoining system or medium. Boundaries tend to be species-rich.

This "edge effect" is an important factor in permaculture. It is recognised by ecologists that the interface between two ecosystems represents a third, more complex, system which combines both. At interfaces, species from both systems can exist, and in many cases the boundary also supports its own species. Gross photosynthetic production is higher at inter-faces. For example, the complex systems of land/ocean interface—such as estuaries and coral reefs—show the highest production per unit area of any of the major ecosystems (Kormondy, E.J., 1959, *Concepts of Ecology*, Prentice Hall, NJ, USA).

Forest/pasture interfaces show greater complexity than either system in both producers (plants) and consumers (animals). It seems that the Tasmanian Aborigines burnt forest to maintain a large interface of forest/plain, since these transitional areas provided a great variety and amount of food. Animals are found in greater numbers on edges, for example, and a fire mosaic landscape is rich in species. Such mosaics were the basis of Australian Aboriginal landscape management.

In view of the edge effect, it seems worthwhile to increase interface between particular habitats to a maximum. A landscape with a complex edge mosaic is interesting and beautiful; it can be considered the basis of the art of productive landscape design. And most certainly, increased edge makes for a more stimulating landscape. As designers we can also *create* harmonic edge with plants, water, or buildings.

There are aspects of boundaries that deserve con-

FIGURE 4. 6
EDGES AND SURFACES.
We can distinguish between many conditions or forms of media (air, water, earth, mud), physical conditions (flow, heat, salinity), and we can manipulate adjacent systems (forest, water, crop, grassland, gravels) to produce landscapes rich in borders, hence species and niches.

1 air/water	2 fresh/brackish	3 warm/cool
4 flowing/still	5 grass/water	6 marsh/water
7 anaerobic/subsoil	8 soil/subsoil	9 stream/bank
10 brackish/salty	11 stream order/sub order	
12 catchment/catchment	13 forest/water	14 water/mud

siderable design intervention:

- The geometry or harmonies of any particular edge; how we **crenellate** the edge.
- Diffusion of the media across boundaries (this may make either a third system or a broader area in which to operate—few boundaries are very strictly defined).
- Effects which actively convey material to or across boundaries; in nature, these are often living organisms or flow (bees, for example).
- The compatibility (or **allelopathy**) of species or elements brought into proximity by edge design.
- Boundaries as accumulators on which we can collect mulch or nutrients.

4.6
THE HARMONICS AND GEOMETRY OF BOUNDARIES

The amplitude, configuration, and periodicity of an edge, surface, or boundary may be varied by design.

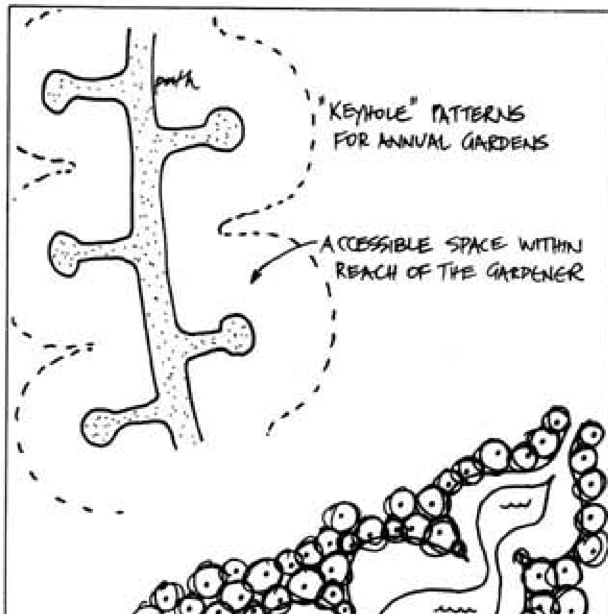


FIGURE 4.7
"Least path" design for home gardens, a keyhole pattern (common in nature) allows us to access garden beds most efficiently. Parallel paths take up to 50% of the area; keyhole beds <30% of the ground. (See also FIGURE 10.26 Gangamma's Mandala).

Edges and surfaces may be sinuous, lobular, serrate, notched, or deliberately smoothed for more efficient flow. While we may deliberately induce turbulence in salmon streams by using weirs, we are painstaking in using smooth and even conduits for energy generation in wind or hydraulic systems. We can deepen areas of shallow streams to make pools, or to prevent stream bank erosion, or to reflect sun energy to buildings; all these are manipulated to achieve specific effects on their boundaries or surfaces.

Notched or lobular edges, such as we achieve in plan by following hill contours, afford sheltered, wetter, drier, hotter, or more exposed micro-habitats for a variety of species. Serrate or zig-zag fences not only stand on their own, but resist wind-throw much better than straight barriers. Lobular embayments, like the keyhole beds of **Figure 4.7**, are obviously sheltered, spacious habitats for gardens and settlements.

As for surface and flow phenomena, we can partition water surfaces to reduce wind effect, or design to deliberately create turbulence and wind overturn. Islands, quoins, and rafts of many shapes have as many uses, and deflect flow to increase condensation or to encourage sand and snow deposition or removal. Surfaces can be pitted, ridged, spiralled, mounded, tessellated, tassled with plants or brush, paved, sprayed to stabilise mulch, mulched, or smoothed for water run-off.

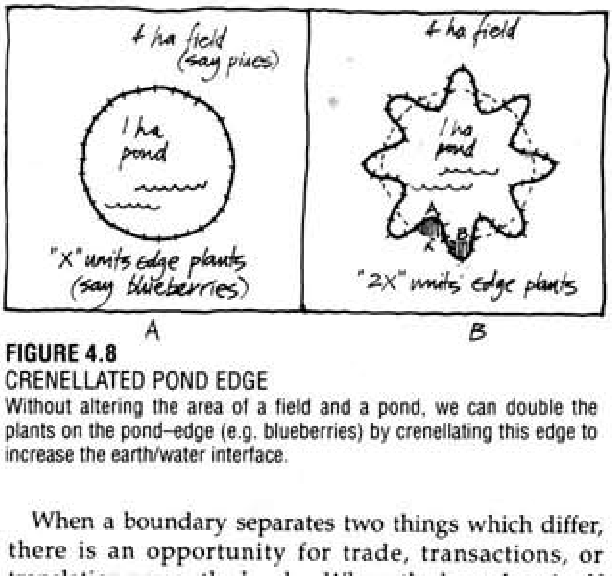


FIGURE 4.8
CRENELLATED POND EDGE
Without altering the area of a field and a pond, we can double the plants on the pond–edge (e.g. blueberries) by crenellating this edge to increase the earth/water interface.

When a boundary separates two things which differ, there is an opportunity for trade, transactions, or translation across the border. Where the boundary itself is difficult to pass, where it represents a trap or net, or where the substances and objects attempting to pass have no ability to do so, accumulations may occur at the boundary. Examples of this lie all about us, as stranded shells on the beach, people lined up at visa offices, and cars at stop lights or kerbsides.

People are, at heart, strandlopers and beach-combers; even our dwellings pile up at the junction of sea and land, on estuaries (80% of us live at water edges), and at the edge of forest, river, marsh, or plain. Invariant ecologies may attract the simple– minded planner, but they will not attract people as inhabitants or explorers.

In design, we can arrange our edges to net, stop, or sieve-through animals, plants, money, and influence. However, we face the danger of accumulating so much trash that we smother ourselves in it. Translators keep flow on the move, thereby changing the world and relieving it of its stresses. The sensible translator *passes on* resources and information to build a new life system.

There are innumerable resources in flow. Our work as designers is to make this flow function in our local system before allowing it to go to other systems. Each function carried out by information flow builds a local resource and a yield.

If you now carefully observe *every natural accumulation* of particles, you will find they lie on edges, or surfaces, or scattered nearby, like brush piled up against a fence (**Figure 4.9**). We can use these processes to gather a great variety of yields.

It follows that edges, boundaries, and interfaces have rich pickings, from trade both ways or from constant accumulations. Our dwellings and activities benefit from placement at edges, so that designing differences into a system is a resource-building strategy, whereas smoothing out differences or landscapes a deprivation of potential resources.

Objects in transit can be stopped by filters and nets. The edges of forests collect the aerial plankton that pass in the winds. Boundaries may accumulate a special richness of resource, as a coral reef collects the oxygen and energy of the sea, and the canopy of the trees the energy of the wind. We rely on translators, such as trees and coral, to store such impalpable resources, to process them into useful products, and to store them for use in their own system, with some surplus for our essential use.

Transactions at boundaries are a great part of trade and energy changes in life and nature. It seems that differences *make* trade; that every medium seeks to gather in those things it lacks, and which occur in the other medium. However, we should also look at the translator, which is often of neither medium but *a thing in itself*, the "connection or path between", created from the media, but with its own unique characteristics.

Plants, people, and pipes are translators. Nets, sieves, passes, and perforations are openings for translators to use, and (as traders know) there is no border so tight that a way does not exist for trade. Go-betweens or traders, like many plants and animals, are creatures of the edge. They seek to relieve the stresses caused by too much or too little in one place or another; or to accumulate resources (make differences) if they operate as storages. We can use naturally-occurring turbulence, trade, and accumulations to work for us, and by carefully observing, find the nets and go-betweens of use. We can use naturally-occuring turbulence, trade, and accumulations to work for us, and by carefully observing, find the nets and go-betweens of use.

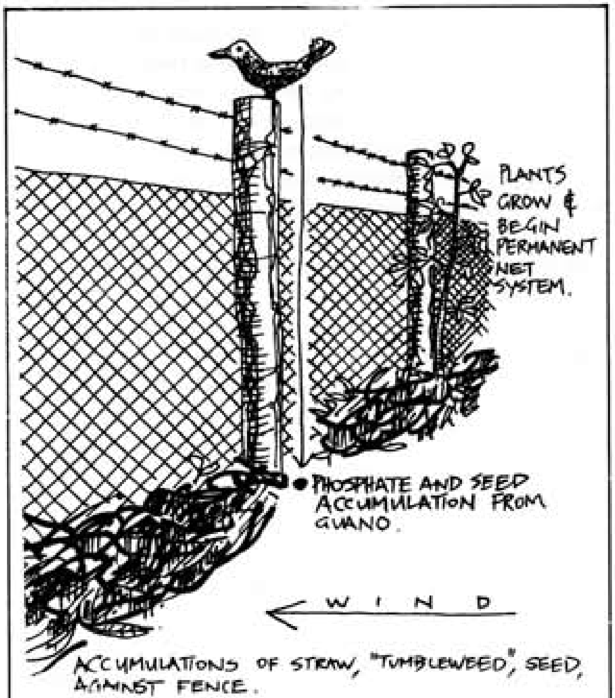


FIGURE 4.9
At powerlines and fences, perched thrushes and wood pigeons defecate, so that each post gains seed and manure, and each may generate a plant from nearby forests. Perches plus disturbed soil produce this result. Fences also act as mulch accumulators across wind.

4.7
COMPATIBLE AND INCOMPATIBLE BORDERS AND COMPONENTS

There are only limited interactions possible between two abstract or real systems brought into boundary contact. The sum of possible effects available are these:

- No difference in yields, stability, or growth (o,o)
- One benefits, at the expense of the other (+,–) (–,+)
- Both benefit (+,+)
- Both are decreased in yield or vitality (–,–)
- One benefits, the other is unaffected (+,o) (o,+)
- One is decreased, the other is unaffected (–,o) (o,–)

Almost all organisms or systems get along fine. A great many derive mutual benefit, and a very few decrease the yield of others or wipe each other out. It simply doesn't pay to attack others. In the long run one destroys oneself by accumulated injury or, more certainly, by pathogens in an animal or conflicts within a society that await a monocultural crop or repressive society. For our domestic plant groups, a powerful design strategy for yield and system stability is to select compatible components for complex edge and surface phenomena.

Many crops, like wheat and pulse grains, trees which bear on the crown, and mass-planted vegetable species, yield much better on the crop edge than they do within the crop. Taking examples where edge yield is marked (e.g. in wheat, lucerne); where there is a (+,+)

relationship, as is the case of crops such as wheat and lucerne (alfalfa); and presuming a two-fold yield increase on edges (it can be more for such trees as *Acacias* with hazelnuts), we can proceed as follows.

First, we need to measure just how far into each crop the edge effect extends, so that we can estimate a finite width of higher yield. We will assume 1 m for wheat and the same for lucerne, giving a 2 m width as a double edge. It is now quite feasible to sow a field in 2 m wide alternate strips of each crop, giving us (in effect) *nothing but edge*, and obtaining from this field about the same yield as we would have had we sown twice the area to single crop stands (**Figure 4.10**).

Two crops are a simple example, but if we extend the principle to many and varied crops on an even broader scale, we approach a new concept of growing, which we can call ZONE or EDGE CROPPING. These would produce a matrix of hedgerows or edge-rows, each suited in width to a particular crop. Such zonal strips are seen naturally occurring on coasts and around saltpans or waterholes.

This sort of setup might be a nightmare for the bulk-cropper (or it may not), but has immense potential for small shareholders in a single land trust, each of whom tend one or more crop strips. It is very like the older patterns of French-intensive agriculture and the farmed strips of modern Quebec, which produce a very productive crop mosaic. Polycultures can be composed of such mosaics or zonal strips.

For cases of (-,-) interactions, both crops suffer, but active intervention with a component acceptable to both systems may work:

Place an intervening, multually-compatible component between two incompatible systems.

Compatible components may simply differ in sex, colour, chemistry, belief, or political conviction from the warring parties. However, in time a beneficial mosaic will impose itself on all expansionist systems, arising from the potential for differences carried *within* all life systems. Natural interveners arise, often as hybrids between apparently antagonistic systems. Our design intention in landscape systems is to build *interdependence into mosaics..*

Select and place components so that incompatibity is nullified, interdependence maximised.

After all, in the absence of tigers, Hindus need Muslims to eat cows; they may also need a Christian businessman between them to effect the transaction. The interdependence of mosaics of belief are called for as much as mosaics of plants.

The stupidity principle may here be stated in a different way:

Stupidity is an attempt to iron out all differences, and not to use or value them creatively.

It is our skill in organising spatial or functional distribution that may create beneficial interdependence in incompatible components. When we know enough to be able to select mutually-beneficial assemblies of plant and animal species

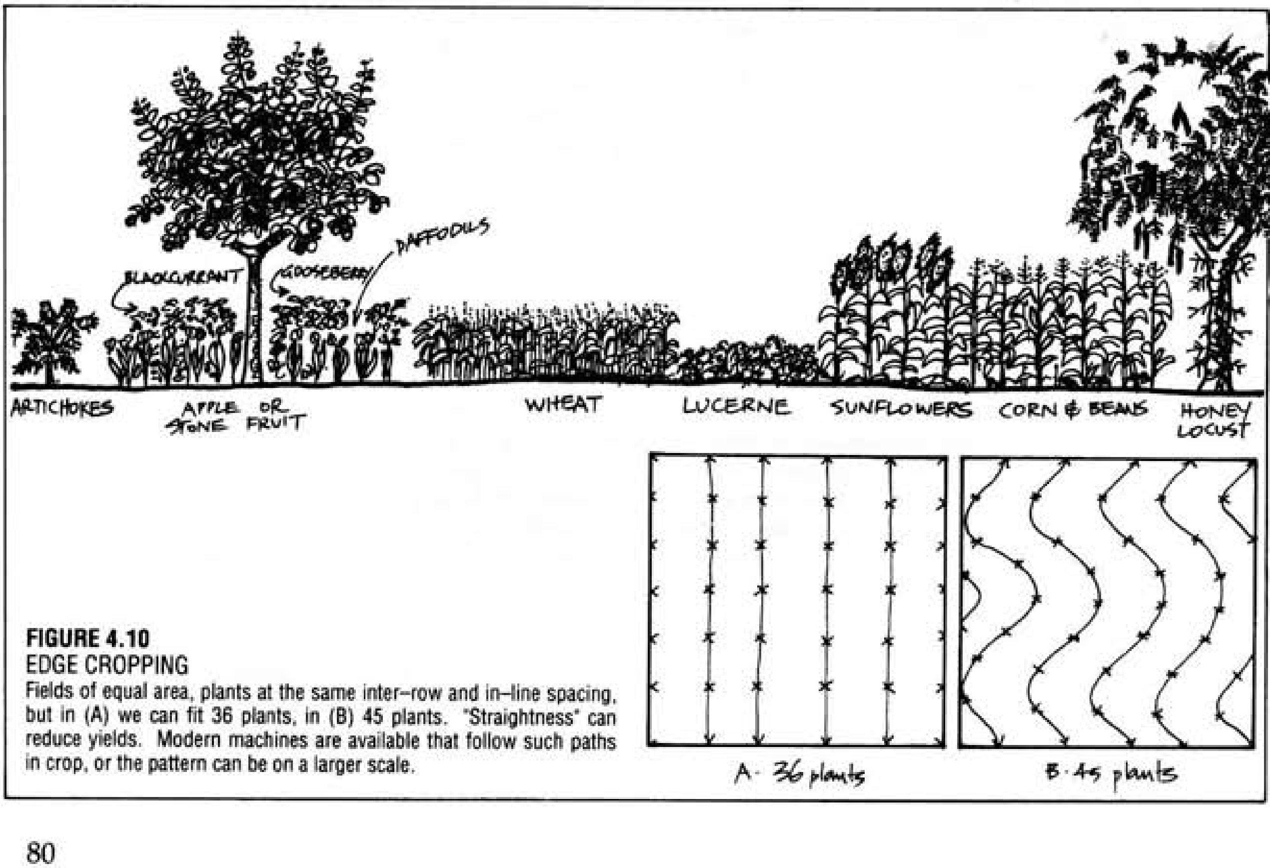


FIGURE 4.10
EDGE CROPPING
Fields of equal area, plants at the same inter-row and in-line spacing, but in (A) we can fit 36 plants, in (B) 45 plants. "Straightness" can reduce yields. Modern machines are available that follow such paths in crop, or the pattern can be on a larger scale.

(**guilds**) then we have two powerful interactive strategies (edge harmonics and species compatibility) for design applications.

Mosaic design (the opposite of monoculture) means the creation of many small areas of differences. A few mistakes will occur, but good average benefit will result. This was the tribal strategy.

A Golden Rule of Design
Keep it small, and keep it varied.

Our tree model is not only *different from* its supporting media, but exists *because of* them. Stress builds *because of* impermeable boundaries. If a fence allows mice through but restricts rabbits, it is the rabbit plague that will break it down. If too much money accumulates on one side of a door it will either force the door open of itself, or those deprived of it will break in. The terrible pressures that gases and molecules can exert are harmless only when that pressure is free to disperse, or where potentially destructive energies are quietly released where there are no boundaries, multiple translators, or stress–relief mechanisms.

Because the event itself creates a third medium, it again sets up stress between itself and the media (M1 and M2). It can be seen, therefore, that *once any one difference of any sort, even an idea, exists anywhere, then it demands or creates conditions for the evolution of subsequent events*. That first event itself became *yet another difference*, which in turn needed translation, and so on. The process is self–complicating, continually creating of itself all that follows, and all that continues. All is stress, or the relief of stress, and that stress and relief is located between existing differences. One difference in the beginning was enough to generate the total range of subsequent events. There are no "new" events, just a continual expression of all possible events, each arising from some recombination of preceding differences. There are no miracles, just a realisation of infinite possibilities. Any event has the potential to spawn all possible events.

There are no new orders of events, just a discovery of existing events.
Every event we can detect is a result of a preceding event, and gives rise to subsequent events.

Between all media, some DIFFUSION can take place. This is greatly enhanced by such phenomena as surface turbulence, wave overturn, temperature differences, and pressure differentials. Boundaries between diffusing media are blurred, often seasonally different or sporadic in occurrence, and always in flux. Plants give pollens and chemicals to air, and actively intervene in radiative, gaseous, liquid, and general energy transactions with the atmosphere. Between plant groups, leaf, root and mulch exudates diffuse as chemical messengers. Water is the "universal solvent" of substances diffusing through the earth's crust, in plant systems, and in the atmosphere.

Diffusion is a quiet process operating on a broad front or over the entire surface of some media. It is analagous to, but differs from, the active transport systems that we have called events or translators. However, once an event has occurred, it *also* uses diffusive processes to gather or distribute materials, and thus *events merely enlarge the total diffusive area available*. A tree may have many acres of leaf, and evapo–transpiration will then exceed evaporation at that place by a factor of forty or more. We can grow many such trees on one acre, and thus increase the diffusion effect by factors of 1000 or more, so that gaseous exchange from leaves, and sugars in soils (or soil life) are both assisted by the trees.

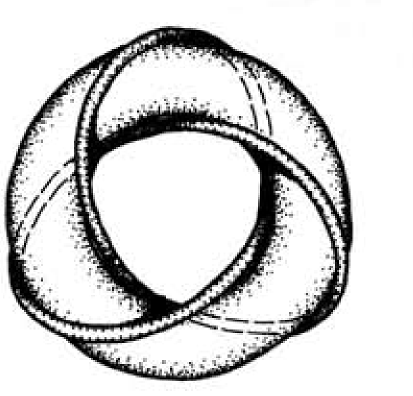


FIGURE 4.11
DNA, coiled around a plus–torus like a single path in the Robinson Congruence.

4.8
THE TIMING AND SHAPING OF EVENTS

We can see how an event takes place, but how is it shaped? Our bodies arise from the origin (O) of a zygote (a fertilised egg) on the surface of the uterus; the placenta is our root, the foetus the tree of ourselves. Animals are thus events broken free from the coiling connective cord or umbilical stem of their origins. Their eventual shape is a pattern laid down or encoded by the DNA of their cells, coiled as it is around a plus–torus like a ribbon around a doughnut (**Figure 4.11**).

When my son Bill was four, we were in the bath together, and he pointed to his toes. "Why are these toes?" he asked.

"What do you mean?" I hedged.

"Well, why don't they get bigger and bigger or longer and longer? Why do they stop at being toes?"

What limits size and growth? All flows pulse, whether they are blood, wind, water, lava, or traffic.

The pulsing may be organised by PULSERS (e.g. traffic lights), and results in WAVES, or time-fronts, or particles on fixed schedules. Such pulsers (**Figure 4.12**) are located in our bodies as chemical or physio-chemical spirals in sheets of cells that swirl in sequence to create a pulsing movement in our heart, organs, and viscera. Pulsers can start, run for a preset time, and stop. This is how we grow, and why we eventually die. All mammals have an allotted number of heartbeats in relation to their body size, and when these run out, we die. (A friend also theorises that we have a set quota of words; and when they are said, we die.)

FIGURE 4.12
PULSERS
Pulsing, here from Winfree's "doped" chemicals, may take the form of spirals revolving about a locus, in this case centripetal in action like a low pressure wind cell. Pulsing is regular in these chemical systems, as in muscle or flow phenomena.

Pulsers *plus* patterns account for shapes. They determine that a toe will stop at being a toe, and not grow into a monstrous appendage or stay as a midget toe. Thus, all living events carry their characteristic time-shape memories, and (it would appear) so do rivers, volcanoes, and the sun itself. The sun "pulses" every 11 years or so, affecting our ozone and climatic factors such as rainfall. Our own pulses have characteristic or normal resting rates, as do our peristaltic or visceral movements.

Pulsers act in concert to create peristaltic or heart contractions, but if they get the wrong signals, can move out of phase and send the organ into seizure. This spasm may cause damage or death (a heart attack). The pulses drive fluids or particles through vessels or arteries in cities and in bodies, and those then branch to serve specific cells, organs, or regions.

Figure 4.12 is a quite extraordinary spiral pattern which arises from the pulsing reactions of organic acids seeded with ionic (iron, cerium) catalysts. The pulses are quite regular, "at intervals of about a minute, but these may vary up to 5 minutes in living systems such as nerve tissue and a single layer of a social amoeba" (Winfree, 1978, "Chemical Clocks: A Clue to Biological Rhythm" *New Scientist*, 5 Oct '78). The system is one of spirals rotating about a pivot point which is not a source but an invariable locus around which a spiral wave is generated. It is sequences of such phenomena that create a peristaltic system. Spirals of this nature can revolve in two senses: either organising material *to* the pivot, or (revolving in the opposite sense) *dispersing* material to the periphery. We can envisage counter-rotating spirals doing both as they do in the circulation of the atmosphere as high or low pressure cells.

The phenomena is shared by nerve, heart, and brain tissue; organic and inorganic oxidation on two-dimensional surfaces; and in thin tissue subject to exciting stimuli. Ventricular fibrilation (a potentially fatal quivering of the heart) may derive from the spasm effect distributed over heart or nerve tissue, causing an "ineffectual churning" (Winfree, *ibid*). It may also account for involuntary spasm in muscle. Spasms can damage the cells of blood vessels, and cause a build-up of scar tissue or cholesterol at the injury site, or in muscle tissue—an area of hard waste products. The social amoeba *Dictyostelium* uses the pattern to move *towards* the pivot point where "they construct a multi-cellular organism which then crawls away to complete the life cycle" (Winfree, *ibid*.), a process resembling the precursor of hormonal control in the nervous system. Some such process may assemble more complex multi-species organisms like ourselves.

The cycling spirals can be found in biological clocks, such as those which govern the 24-hour metabolism of flowers and fruit-flies, stimulated by oxygen or light pulses.

Within a specific organism, specific pulsers exist; the 24-hour rhythm (CIRCADIAN) of birds is controlled by the pineal gland (*New Scientist*, 11 Oct '84) which secretes a regular nocturnal pulse of the hormone MELATONIN (the changing levels of melatonin trigger the annual cycles of breeding and nest-building in birds). Visual perception of light changes and day lengths regulate the production of melatonin in the pineal gland. Even small pieces of the gland in isolation will respond to light, and can be disrupted by flashes of light (as in lightning) at night. Thus, we see that not only expansion, but DISCHARGE PHENOMENA such as lightning (or sudden shock in people) disrupt or trigger initiatory reactions in life rhythms, and introduce irregularities in cycles or pulsers, just as expansion or shock introduces irregularity in fixed forms. The question arises as to whether the disturbance produced by shock or sudden stimulus is responsible for expansions, cyclic changes, or shape deformations on a more general scale.

Species and individual organisms need both SHAPERS (DNA) and TIMERS (biological clocks) to achieve a specific size and shape. The two must work synchronously to achieve the correct proportions of parts such as fingers and toes, but both are critical to the organism.

Branching patterns in bodies must have (already encoded) the correct angles and placements for their main branches, leaving room for sideshoots and forks, but not for interweaves or cross-points which damage the function of the organism. In order to generate the surface or boundary of a person, and their reticulation systems, patterns of incredible complexity and strict limits must be "known" by the cells or the cell organisers.

We ourselves are part of a guild of species that lie within and without our bodies. Aboriginal peoples and the Ayurvedic practitioners of ancient India have names for such guilds, or beings made up (as we are) of two or more species forming one organism. Most of nature is composed of groups of species working interdependently, and this complexity too must have its synchronistic regulators.

4.9
SPIRALS

Implicit in many of the phenomena discussed are the forms of spirals. These may be revolving (dynamic) or fixed (static), and arise as a consequence of deformations in flow, or are rather an intrinsic property of a specific velocity of flow over surfaces. Other spiral paths are traced out by orbiting bodies over time, or are shapes developed by organisms developing a compact form (e.g. molluscs) that is analagous to annidation. Spiral forms are made visible by plants as whorls of leaves and branches.

D'arcy Thompson (1952) in his book *On Growth and Form*, discusses some of the quantitative or geometric qualities of spiral phenomena, which are hidden or revealed in many natural forms. A long spiral in section is the "S" form of humid landscape slopes (and the yin-yang symbol). Three-dimensional spirals form long ribbons of complex shape. Even within the molecular forms of matter, DNA reveals a double-helix form. Spirals are, in effect, single streamlines of vortices, tori, or sap flows.

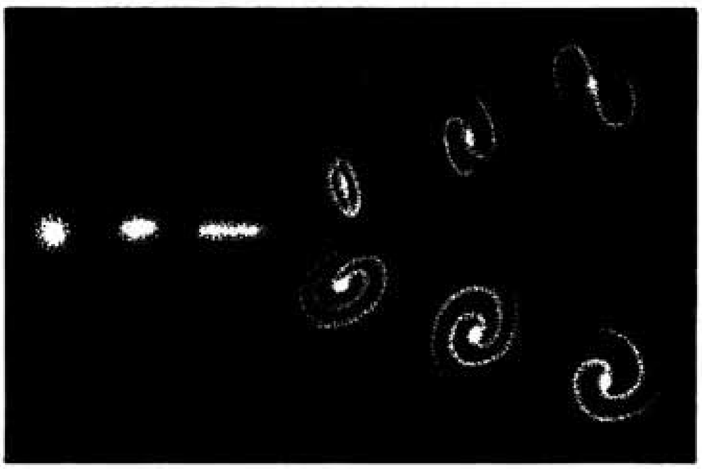
Spirals arise from the interaction of streaming and its subsequent deflection of flow around vortices. Storl (1978, *Culture and Horticulture*, Biodynamic Literature Rhode Island) points out the spiral arrangement of leaves in many plants, where leaves are from one-half way, one-third way, and so on around the stem from the preceding leaf, or to the next leaf. Such placements may progress in a regular (Fibonacci) series, each following on from the sum of the two preceding ratios: 1:2 + 1:3 = 2:5; 1:3 + 2:5 = 3:8, etc., so we get 5:13, 8:21, 13:34 and onwards. These sequences are found in plants and in planetary orbits, so that "Venus forms five loops (retrogressions) below the ecliptic in eight years." Storl sees a relation between the forms of plants and of planets in these progressions, as we can see in the orders of size.

Like so many real-life phenomena, natural spirals are not "perfect", but "show slight progression" and gradually lose phase over long periods (Storl, *ibid*). We can often use the spiral form in design, both to create compact forms of otherwise spread-out placements and to guide water and wind flows to serve our purposes in landscape. We can see the application of spiral forms to technology in everyday life as screws, propellers, impellers, turbines, and some gears. Some species of sharks and invertebrates develop spiral gut lining to increase absorption, or spiral cilia to convey mucus and food or particles in or out of the organism. Plants such as *Convolvulus* use spiral anchors in earth, as do some parasites in animal flesh.

Thus, spirals are found where harmonic flow, compact form, efficient array, increased exchange, transport, or anchoring is needed. We can make use of such forms at appropriate places in our designs.

4.10
FLOW OVER LANDSCAPES AND OBJECTS

The simple involuted mushroom, called an "Overbeck



HUBBARD'S GALACTIC CLASSIFICATION
Regular and usual galaxies have limited forms (eliptical, spiral, or barred) and slow rotations. Even galaxies can be ordered in terms of form.

jet" by D'Arcy Thompson (1942), is also shown in its "apple core" model form in **Figure 4.13**. While we can produce these patterns by jetting smoke, fluid, gases or oils into other media, they occur as a part of the natural streaming of fluids and gases past fixed objects such as bluff bodies (e.g. posts) in streams, islands in tides, and trees in wind. Jet streams at altitude can generate such vortices by pushing into different air masses, as can muddy water entering the sea.

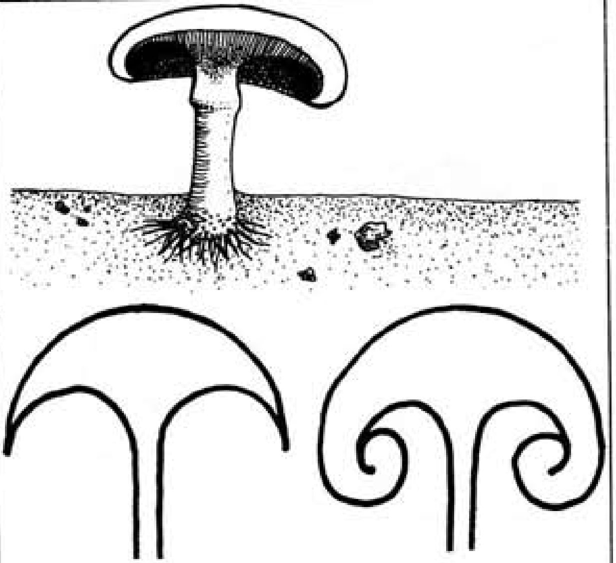


FIGURE 4.13
OVERBECK JET MODELS
The Overbeck jet is a simple half-form of the basic model, and occurs commonly in nature e.g. mushrooms, rivers flooding into the sea, and jellyfish.

Whirlpools or VORTICES are shed alternately from a fixed bluff body located in flow, each side generating its own vortex, each with a different rotation. Beautiful and complex forms are thus generated (**Figure 4.14**) and these are the basis of the work at the Virbela Institute on flowforms. The sets of vortices shed or generated downstream from fixed bodies in flow are called Von Karman trails.

The trails are stable at the 1:3.6 ratio shown in **Figure 4.14**. In many streams, and on foreshores, the clay-beds, silts, and underlying rock may develop such patterns, and posts fixed in streams commonly produce them in water. Trees and windbreaks produce similar effects in wind, as do waves at sea. In wind, they are called EKMAN SPIRALS, and in air the spiral lift effect compresses air streamlines to a height 20–40 times the height of the tree or fence fixed in the air flow.

It is obvious that the stable spirals of the Von Karman trails will produce successive pulses downstream, and this is in fact how we observe most flow phenomena to behave. Thus the pulsing of wind, water, and flow in general may rely on the elastic or deformation properties of the medium itself rather than on electro-chemical "timers" as found in organisms. In nature, there are many fixed impediments to perfect streamlined flow.

It is typical of Von Karman trails generated from a fixed body that the effect persists as 4–5 repeats (**Figure 4.14. C**), and then the stream of water gradually resumes streamlined flow. At higher velocities of stream flow, chaotic turbulence occurs, and at slower velocities, simple streaming persists around objects. Thus we see that the Von Karman trail is just one form

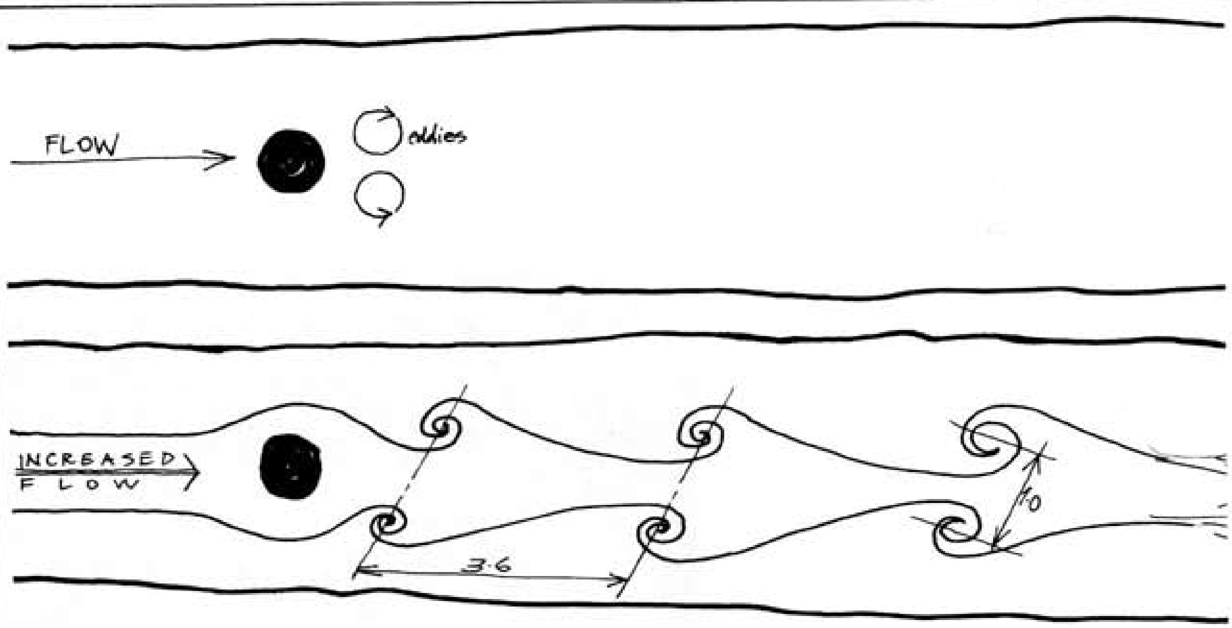


FIGURE 4.14
MOVEMENT OF WATER PAST BLUFF BODY (VON KARMAN TRAIL).
At certain modest flow speeds, water, wind, and even clouds form a stable 4 to 5 series train called a Von Karman trail; such phenomena were vital guides to Polynesian navigators (see Figure 4.26).

of pattern generated by specific flow conditions. It is nevertheless a common form in nature.

The spiralling of wind over tree lines produces a secondary effect, analagous to the streaming of tides around atolls; the wind *changes direction* past the obstacle (about 15°). Such effects may occur within media of different densities (temperatures) as when warm high-pressure wind cells ride over colder low-pressure fronts. The temperature, pressure, and velocity of wind or gas systems are often related:

- Low pressure – high velocity – cool temperature – (expansion).
- High pressure – low velocity – warmer temperature – (contraction).

Velocity in gases and fluids is strictly governed by contact with stationary surfaces, so that the velocity is effectively nil very close to static surfaces, increasing as a series of (imaginary) laminar sheet flows above that surface (**Figure 4.17**). This is the effect that is observed in viscous flow in small canals or vessels, and that governs the shapes and strategies of organisms such as limpets and starfish.

Thus, we see that media in flow can produce pulsers, vortices, and spirals as a result of irregular or obstructing objects or resistant media, and that these phenomena are interconnected.

The relationships between fluid flow, boundary conditions, and the form these impose on organisms is clear from our pattern models and their deflection states. Life as evolved by its internal and external patterns and flows is very well discussed by Vogel (1981) in a lively and scholarly book entitled *Life in*

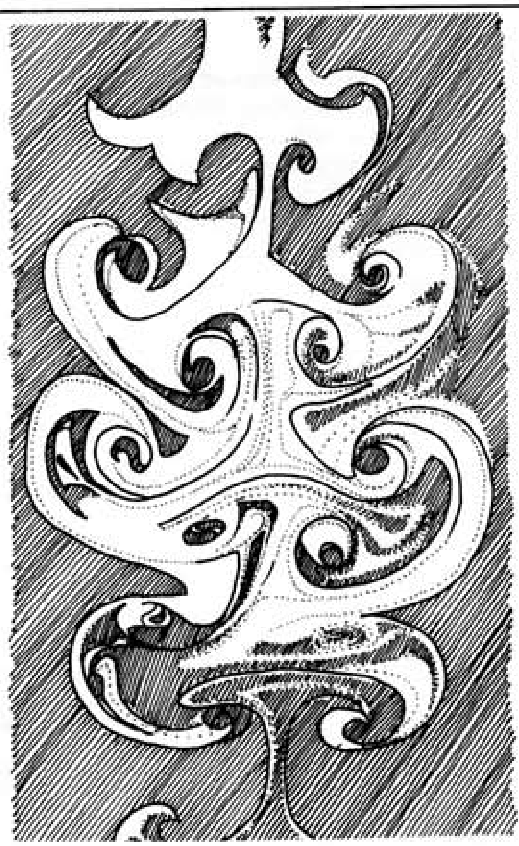


FIGURE 4.15
MOVEMENT OF BLUFF BODY THROUGH WATER.
A bluff body drawn through still water can make a theoretically endless trail of Overbeck jet forms, superficially resembling a Von Karman trail.

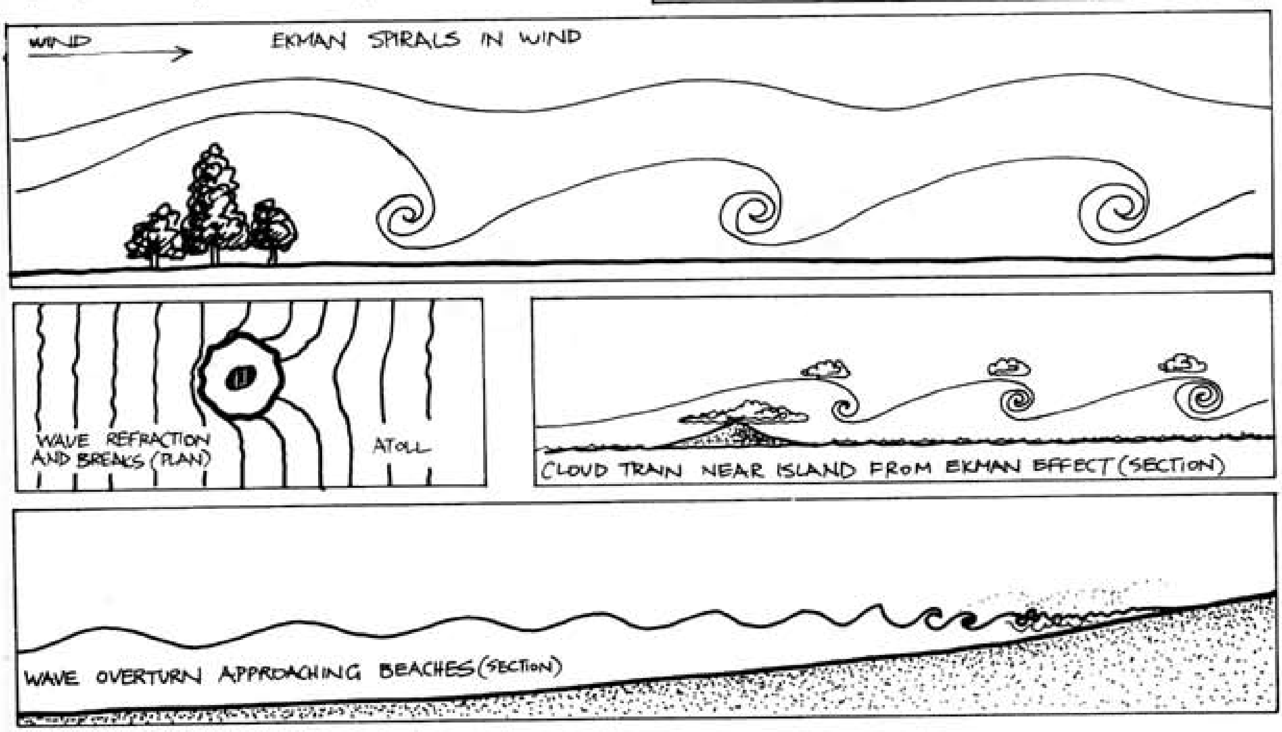


FIGURE 4.16
DIFFERENT TYPES OF TRAILS AND SPIRALS.
The effects of fixed bodies on wind, waves, tides, and cloud streets; various phenomena arise from flow forms.

Moving Fluids.

Carried in the flow of media, as a thistle-down in air, are many events looking for a place to happen. A "net", resting surface, or detonator is needed for these potential events to express themselves. We can provide many such receptors or triggers in our design systems, catching nutrients in flow and ensuring events for future growth in our system. Some such nets form starting-places for events, while others are resting or death places for those entities dependent on flow, or stranded out of their nutrient media.

Just as a series of corks floating on the sea have a predictable path to shore perpendicular to the wave fronts, so does matter flow in a wave-tank model. Similarly, drift-lines form at sea (STREAMLINES in the core model), and as these end on shorelines, they deposit or remove material.

It is along these streamlines that energy acts, by medium of the waves of growth or surface waves in motion. This is how the event and its material expands: streamlines diverge as wave fronts and *disseminate* into open media, but are strong, concentrated, and visible at constrictions, near origins, or in powerful or refracted flows. A small restricted orifice in the time-front or wave-front acts as a secondary origin. Just as a grub encircling a tree causes it to branch out at that point, so constrictions in the flow of

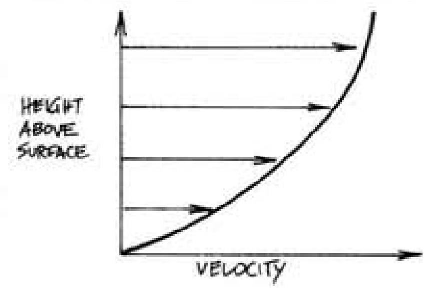


FIGURE 4.17
DIAGRAM OF LAMINAR SHEET FLOW.
Surface drag greatly affects stream flow in water or air. Velocities near a surface are close to zero, giving viscous flow, and only slowly increase as distance from the surface increases.

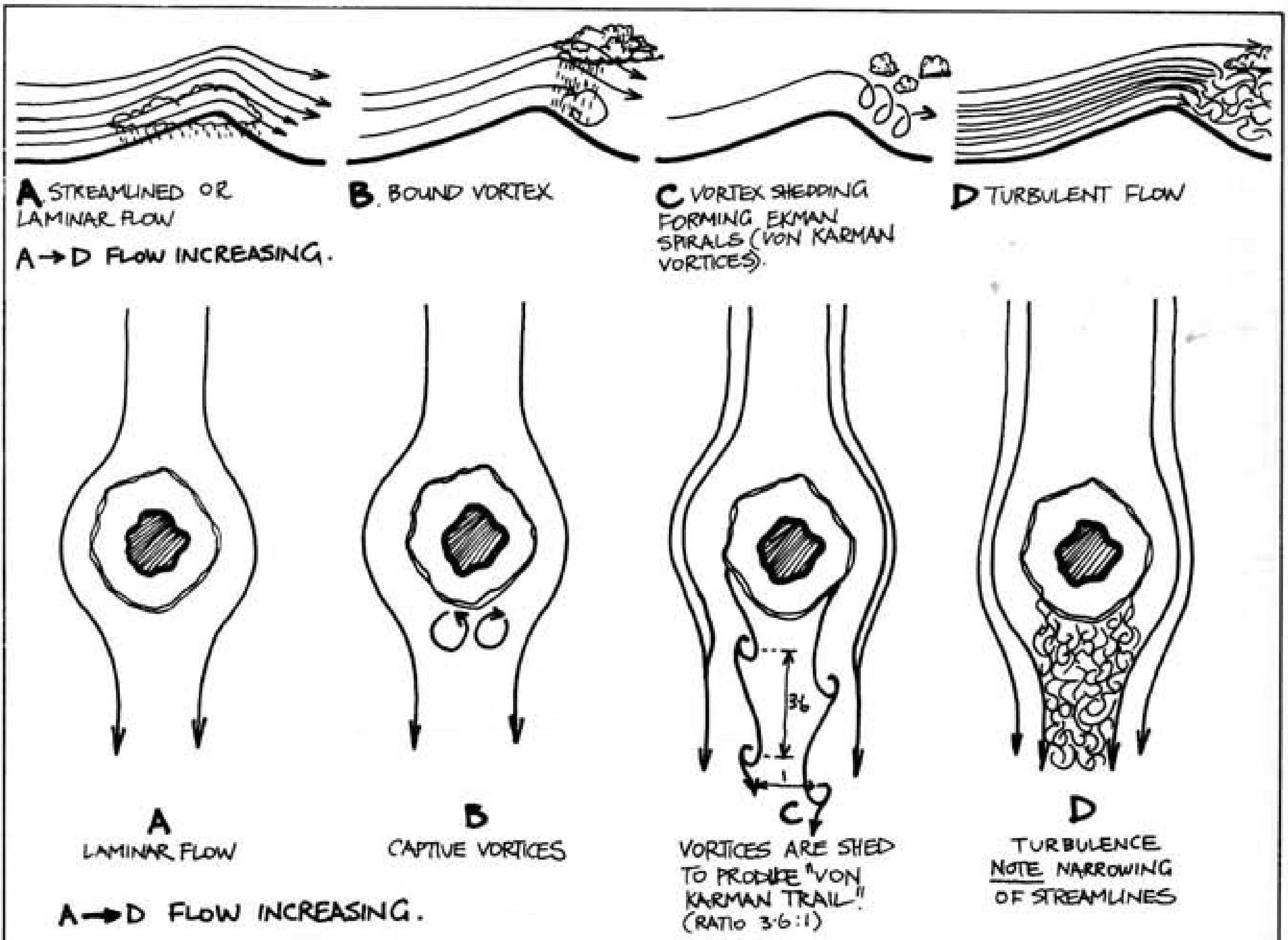


FIGURE 4.18
MEDIA IN FLOW
Flow at different velocities produces different downstream phenomena. Here velocity increases from A – D, as wind over an isolated island, or current flow past an atoll.

events generate secondary origins. I once watched this happen with a eucalypt that I planted in 1953, and saw it twin and twin again as swift-moth grubs encircled its stem. It is now a mighty tree, much branched, but the evidence of these minute constrictive events are still buried in its stem. As designers, we can impose small constricting events or place fixed objects in flow to produce such specific results. We can then be the external shapers of patterned events.

4.11
OPEN FLOW AND FLOW PATTERNS

Creatures that live in open flow conditions are specially shaped and adapted to surface or low-flow (high pressure) phenomena, and may erect or develop "chimneys" to draw fluids or gases through their burrows or bodies. Some life forms combine chimneys, spirals, and crenellations to effect an exchange between them and their fluid surrounds (Vogel, 1981).

All of these effects of flow are of great relevance to designers, engineers, and biologists, and their effects can be increased, nullified, or decreased by design. Natural effects can be used in a variety of ways, and the effects of orders may impose limits on design. Further data is given under Chapter 6: "Trees and Energy Transactions".

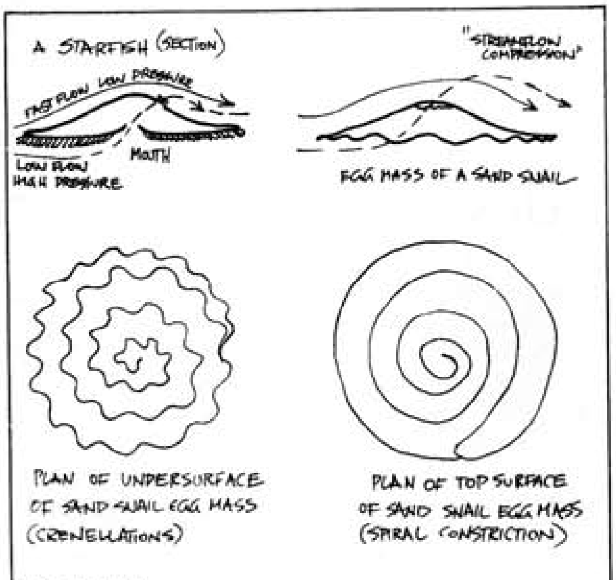


FIGURE 4.19
LAMINAR FLOW NEAR A SURFACE
(Arrows represent wind or water speed). Pressure is high near the surface, lower at a distance, thus a starfish (or a chimney) experiences a flow "under and out the top" in flow conditions. The sand snail egg mass is built to be easily irrigated, the starfish gets food in the water stream by their configuaration in flow.

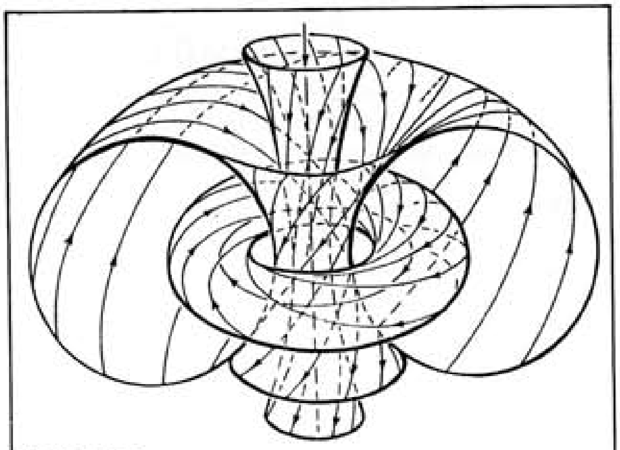


FIGURE 4.20
THE ROBINSON CONGRUENCE
Pattern for an electron, a massless particle, travelling up this page at the speed of light; energy as form, congruent also with the general model.

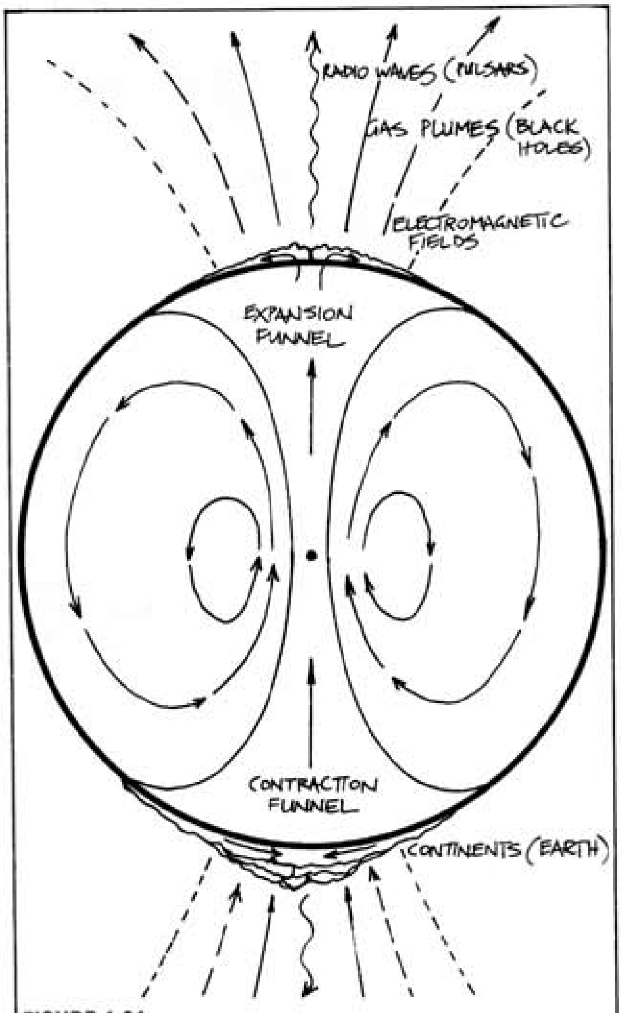


FIGURE 4.21
MODEL OF SPHERICAL BODIES IN SPACE.
A simplified model of a dense planetry body (c.f. the general model). Electro-magnetic fields and thermal convection create special conditions along the axis of spin. Many such bodies emit material at the poles before cooling.

4.12
TOROIDAL PHENOMENA

Implicit in our core model, and obvious in violent detonations such as atomic explosions, puffs from diesel exhaust pipes, or deliberately blown as smoke rings, are the rolling doughnut-shapes of TORI. A TORUS is a widespread natural phenomenon. The closed models (**Figure 4.13**) enclose such a torus, and we can imagine a slow-cycling torus of nutrients surrounding the stem of any tree as crown-drip carries nutrients to the ground, and the roots again return them via the stem of the tree.

Photographic stills of atomic explosions may reveal violently rotating tori around and crowning the ascending column of smoke and debris. Violent up-draughts caused by local heat create such tori in atmospheric thermals, much appreciated by soaring birds and glider pilots, who ride the inner (ascending) circle of the doughnuts of hot air that are generated, for example, over deserts on hot afternoons.

A complex toroidal form is the "Robinson Congruence" (**Figure 4.20**), portraying the space-time form of a mass-less particle such as a proton, representing, in effect, annidated tori.

DNA is also portrayed as encircling such an imaginary plus-torus in **Figure 4.11**. A Möbius strip—a one-sided twisted toroid (often portrayed by M.C. Escher in his art)—enables us to cross an edge without lifting our pencil. Many life forms produce tori (e.g. some sea snail egg masses). We rely on a torus of rubber to inflate our tyres and to seal circular hatches as O-rings.

A torus is, in effect, a special or truncated case of the Overbeck jet (**Figure 4.13**), as a foetus is a truncated "tree", and can be generated by *discontinuous* or explosive flow, or pulses in flow. A torus is a closed three-dimensional vortex. One such closed toroidal form, as found in black holes, is shown in **Figure 4.21**. Here, accretion of matter causes gaseous ejection at the poles, as the earth may have "ejected" seas and continents at the magnetic poles, or gathers in the violent energy of ionised particles that form the auroras, visible as polar tori in satellite images. Even the long curtains of the auroras seen from the ground contain vertical spiral columns (J. Reid *pers. comm.*).

4.13
DIMENSIONS AND POTENTIALS; GENERATORS

Our patterned systems may exist in two or more dimensions. We can tessellate two-dimensionally but need to envisage three dimensions for a tree form or glacier. The tree-forms of rivers flow down along S-shaped gradients; the generator of such a pattern is gravity. Sand dunes form on near-flat platforms of the desert, and have wind as their generator, as do waves on the sea. Neither gravity nor wind may much affect the creeping tree patterns of mosses, dendrites in shales, or the tree-like forms of mycorrhiza in plant cells. It is here that we see our tree form as the best way to grow or to gather nutrients in the absence of violent kinetic processes. The generator here is life or growth itself.

When kinetic forces do not act strongly, as in flat and essentially sheltered desert environments, **lobulation** and **latticing** still occur as freeze-thaw or swell-shrink patterns, as they do in ice floes on quiet ponds or in the hexagonal patterns of stones on tundra. The slow growth of crystals into rock cavities or ice is still related to our general model; the generator of pattern here being at the level of molecular forces, as in many purely chemical processes, and the forms generated are fractals.

In hill country, energies are usually a combination of stream flow and gravity. On plains, icepacks or flat snowfields, it is freeze-thaw or the swelling of clay in rain that produces lobulations or networks of earth patterns. Lobulation, the production of such shapes as in **Figure 4.7**, differs in origin and mode of expression from the kinetic-energy (flow) systems we have been discussing. I sometimes think of the lobulated forms as a response of nature, or life, to a world that threatens "no difference".

If the hills wear down, then the antepenultimate surfaces will produce their lateral, two-dimensional life patterns, as does the lichen on a rock. Kinetic erosion processes are then exchanged for physical and chemical process at the molecular level, but even this creates a sufficient difference in media for life forms to express themselves, and for differences to arise in the patterns of surfaces.

4.14
CLOSED (SPHERICAL) MODELS; ACCRETION AND EXPULSION

Although trees (including tree roots) may approach spherical form, the best examples are found in spherical bodies in space. These deflect light, dust, and gas towards them, and may capture materials. In their early formation, they themselves may have had dense cores that assembled their share of galactic materials, and around these cores a torus of matter of low- or high-speed rotation can form. This is the model presented for most bodies (*New Scinetist*, 4 April '85, pp. 12-16). A general model is given in **Figure 4.21**.

As matter accumulates in this way, bodies can respond by:

- Becoming more dense – to a limit of 10^{14} g/cm^3;
- Swelling or expanding (producing shatter effects); and
- Ejecting material at the poles.

Or any combination of these depending on the state of the matter attached or attracted to the core.

For pulsars, the ejection is radio waves, and for black holes high-speed gas plumes. For trees, of course, we find expansion and transpiration, not localised to the axis of growth.

However, along the Z–Z (ejection) axis of **Figure 4.1**, rotating tori speed up ejection at north poles, and slow it down at south poles, so that less viscous materials are likely to be emitted at north polar emitters. This general effect may be portrayed in one model, but each case needs study. Weak gravitational waves permeate the astronomical system as pulsers permeate or orchestrate biological systems, aiding both dispersal and accumulation depending on the sense of rotation of the accreting system, or the electromagnetic fields interacting with incoming particles. It seems probable that weak fields within the sun creates its pulsers, which proceed from pole to equator as a roll or torus of turbulence over an 11-year period.

4.15
BRANCHING AND ITS EFFECTS; CONDUITS

Various sections, plans, and views of our one tree model reveal very different sectional PATTERNS, all of which are inherent and most of which recur in many other natural forms. Benoit Mandelbrot assembled his own insights, and the speculations of others, to found a mathematics of **fractals** (his term, from the Latin *fractus*, or shattered), which is evolving to make sense of irregular phenomena, as Euclid did for more regular and measurable forms (*New Scientist*, 26 Apr '84, p.17 and 4 Apr '85, p.31–35).

Fractals are as common in nature as in abstractions, and examples are as diverse as impact shatter-zones, clouds, forked lightning, neurone nets and their signals, computer searching procedures, plant identification keys, snowflakes, and tree branches or roots. Some typical fractal forms are illustrated (**Figure 4.22**). Others make up the complex lengths of coastlines and the intricacies of turbulence.

In our tree form (**Figure 4.1**), these fractal patterns (as branches and roots) are contained within a form that would be comprehensible to Euclid, having straight axes, a plane, and regular curved lines, which can be drawn as arcs of perfect circles. Thus the apparent chaos of fractals can be seen to underlie quite regular (but never perfect) shapes in nature as branches underlie the crown canopy of a tree. As Mandelbrot has demonstrated, fractals have their own regular generators and evolutions.

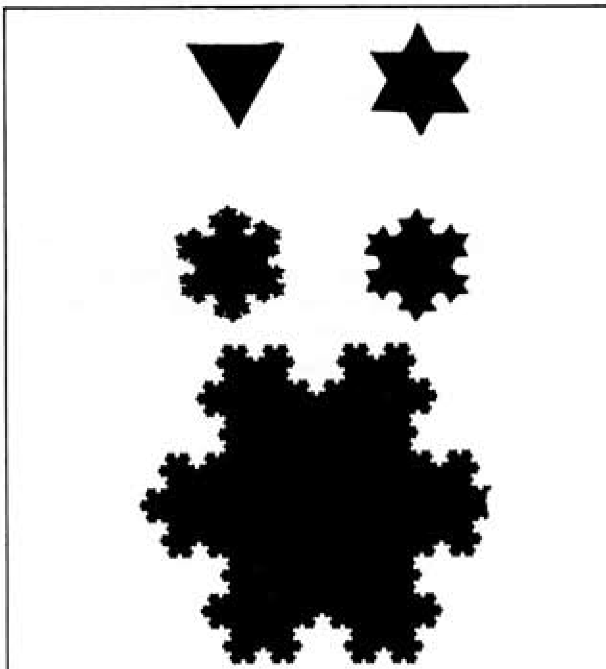
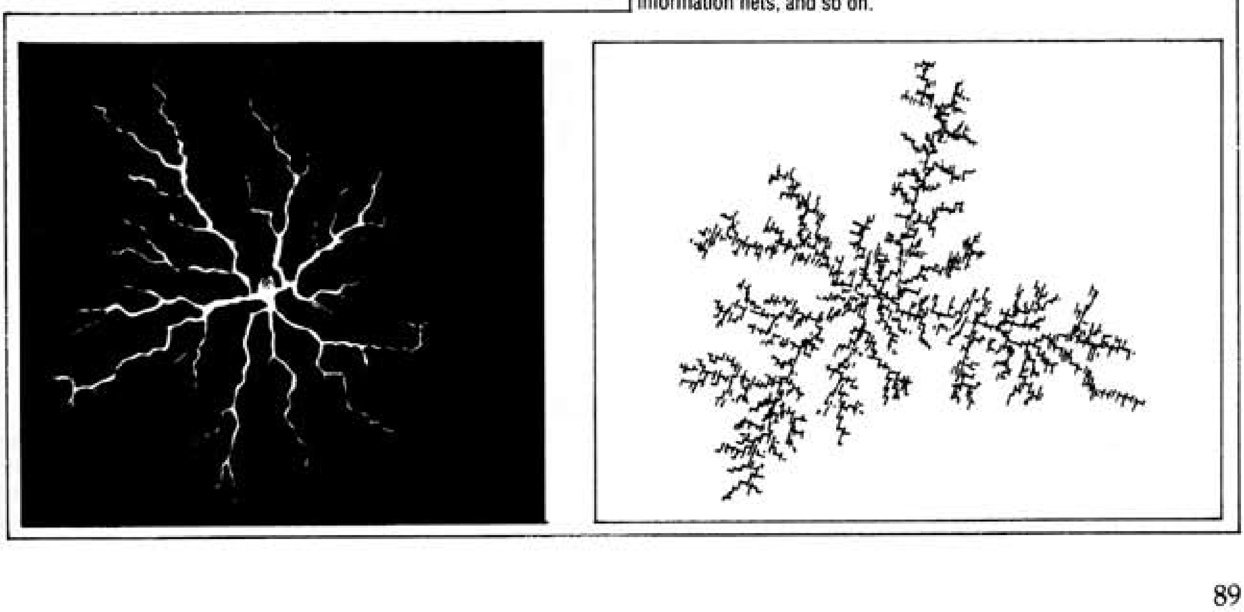


FIGURE 4.22
SOME FRACTAL FORMS
Fractal forms mat be generated by repetition of relatively simple form generators, as are some crystalline formations and such phenomena as tree roots, tree branches, coasts, lightning strikes, shatter zones, information nets, and so on.



Looking down on a bare winter-deciduous tree, we see a typical fractal, which we can also find in the fulgurites (sand fused by lightning) in sand dunes, and in the shatter zones of explosions. Tree roots are, in fact, a slow shatter or explosion underground. One way to plant an apple tree in very hard ground is to detonate a small plug of gelignite a foot or two below the surface; the roots will follow the shatter pattern, and further elaborate it.

Scatters of objects may at first seem to present a class of events unrelated to either flow models or frac-tals, but fractals are being used to describe the scatters of tree clumps in grassland, or lichen on a stone. In a sense, the surface of spheroids created by branched phenomena (like the plan view of a tree crown) may show such apparently random scatters as growth points; or a curved section through the cut or pruned branches below the crown of a tree would also appear to be a scatter of points (**Figure 4.1.E**). These can be measured by fractal analysis.

Fractal theory may give us a way to measure, compute, and design for branched or scattered phenomena, but we also need to understand the physical advantages of developing ever smaller conduits. Vogel (1981) gives many insights into this process and its effects. Large conduits are of use in mass transport, but both the laminar flow patterns within them and the fact that they have a small surface area relative to their volume makes them inefficient for the *diffusion* of materials or the conduction of heat across their walls.

Ever smaller conduits have different qualities: flow is slow, almost viscous in very small tubes or branches; direction changes in small branches are therefore possible without incurring turbulence or energy losses. Walls can be permeable, and efficient collection, exchange, and transfer is effected (whether of materials or physical properties such as heat and light). Many small conduits efficiently interpenetrate the exchange media.

Wherever there is a need to collect or distribute materials, or to trade both ways with media, branching is an effective response. In design, therefore, we need to use "many paths" in such situations as home gardens, where we are always trading nutrients as our main activity. There is little advantage in forming these paths as straight lines (speed is not of the essence), but rather in developing a set of *cul de sacs* or keyhole-shaped beds (this is also the shape of sacs in lungs). Convoluted paths in gardens have the same effect. They either bring the gardener into better contact with the garden, enabling collection and servicing to occur, or create better mutual exchange between the species in the garden.

The high-pressure/low-flow nature of minor branches demands a very large total cross-sectional area of these in relation to the main supply arteries. Such small conduits may develop areas which in sum are 300–1,600 times that of the supply artery (our main roads are therefore much less in area than the foot tracks that lead off them). As an applied strategy, multiple small paths enhance our access to food systems, or in fact any system where we both take and give materials.

In organisms, the multiple branches give the being a chance to recover from injury, preserve information, and permit regrowth in the event of minor damage. It is a fool-proof system of interchange. Another way to effect interchange is to elaborate on the walls of larger conduits by involutions, attached fins, irregular surfaces, or to create spirals in fluids or gases by bending or spiralling the conduits themselves, and in general inducing a larger surface of contact between the material transported and the media with which we wish to exchange nutrients, heat, or gases.

Branching in trees is as often a result of external forces (wind and salt pruning, secateurs, or insect attack) as it is a result of internal cell patterns; it is as much forced upon things as it is the "best thing to do." We must therefore see the branched form as an interaction between an organism or process, the purpose it serves, and the external forces of the media in which the organism is immersed (the forces acting on it externally to deform the perfect pattern).

Along the streamlines (S1–S9 of our model **Figure 4.1**), fluids and gases may pass in conduits or along "transmission cords", food and signals are relayed to cells, and gases exchanged. Organs served by or serving these systems are half-models of our tree (kidneys, lungs) or branching fractals (mesenteries).

No matter how long or complex conduits are, in the end their contents diverge, escape, and disperse, and at the intake materials are gathered from dispersed sources. It is this gathering and dispersal from both

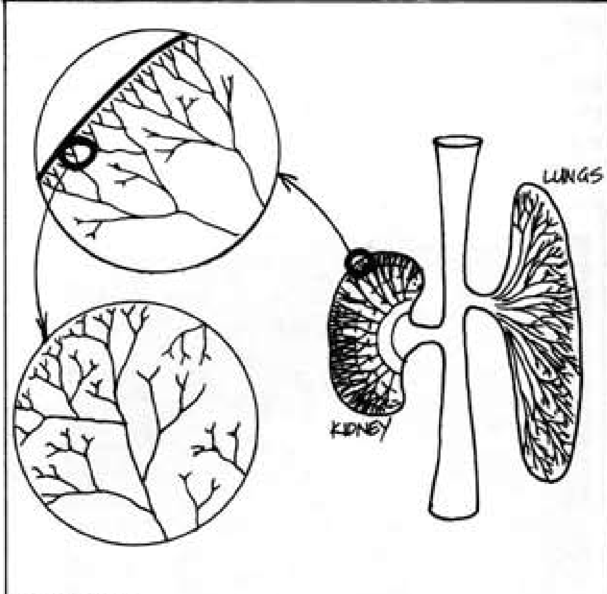


FIGURE 4.23
Any form specialised for diffusion or infusion (lungs, kidneys, mushrooms, palm trees) is usually subject to branching, and develops a "half-model" in one medium. The alvioli of the lungs further resemble the "keyhole beds" of a well-designed garden.

ends or margins of events that is a basic function of the tree–like forms that pervade living natural systems and such phenomena as rivers or lava flows.

4.16
ORDERS OF MAGNITUDE IN BRANCHES

Streams take up many ground patterns depending on the processes that have formed the underlying landscape (block faulting, folding, volcanism) and the erosion and permeability characteristics of the underlying rock itself (limestone, mudstone, sandstone, clay). That is, the ultimate pattern of a stream network in landscape depends on *process* and *substrate*; or we could call these process and *media* in terms of our model.

We can easily see that stream patterns are the sum of preceding events that gave rise to the geological processes and rock types, so that streams have a lot to tell us about such processes, a skill learnt in photo interpretation. **Figure 4.24** demonstrates some of the information so clearly told by stream patterns alone.

However, if we abstract a fairly normal dendritic (tree–like) stream branching pattern as in **Figure 4.25**, we can find out these things from the pattern alone:

- The ORDER of channels; the volume, or SIZE, of branches.
- The NUMBER OF BRANCHES in each order.
- The TOTAL CHANNEL LENGTH in each order.
- The MEANDER FREQUENCES in each order, or the behaviour of flow in the orders of branches.

Streams usually have from one to seven orders, depending on their age, size, or gradient (fall over distance). An easy gradient develops as streams cut back their headwaters and fill in (aggrade) their lower reaches; meanders increase, and the velocity of flow decreases. These older streams, like a mature tree, have developed all their branches (as has an old company or an old army). Unless stream conditions themselves change (by a process of stream capture, an increase in rainfall, or a change in landscape), streams (and businesses) maintain an equilibrium of order. Looking at our dendritic, peaceful stream, we may find something as can be seen in **Table 4.1**.

As the branches join up to make ever larger orders of channels, then about 3 times as many smaller branches join up to make each larger group, and so on. However, the individual lengths (of any one branch in each order) increase by 2 times as the order increases from 1–6. This is a very general rule of stream branching, even in non–dendritic patterns, and holds true for many streams. Similarly, meanders or bends also occur in a predictable way depending on the volume and gradient (flow). Regular meanders depend on certain velocities and stream width (as do stability of Von Karman vortex trails; **Figure 4.14**). The ratio for meanders or trails is about 1:3.6 (Vogel, 1981).

Such regularity in branching may remind us of PULSERS (wave fronts), and indeed as each size order changes, so does the behaviour not only of the water flow, but of its associated flora and fauna and their shapes. In the rills and runnels, streamlines and turbulent flow is observed. High in the stream gradients (the flattened S–curve of the stream bed in profile) we find insects and fish with suctorial parts able to stick on rocks, flattened fins to press them into the stream bed, flattened bodies and very streamlined profile. In the middle orders, we get less turbulent water flow, more spiralling, less oxygenation, and more

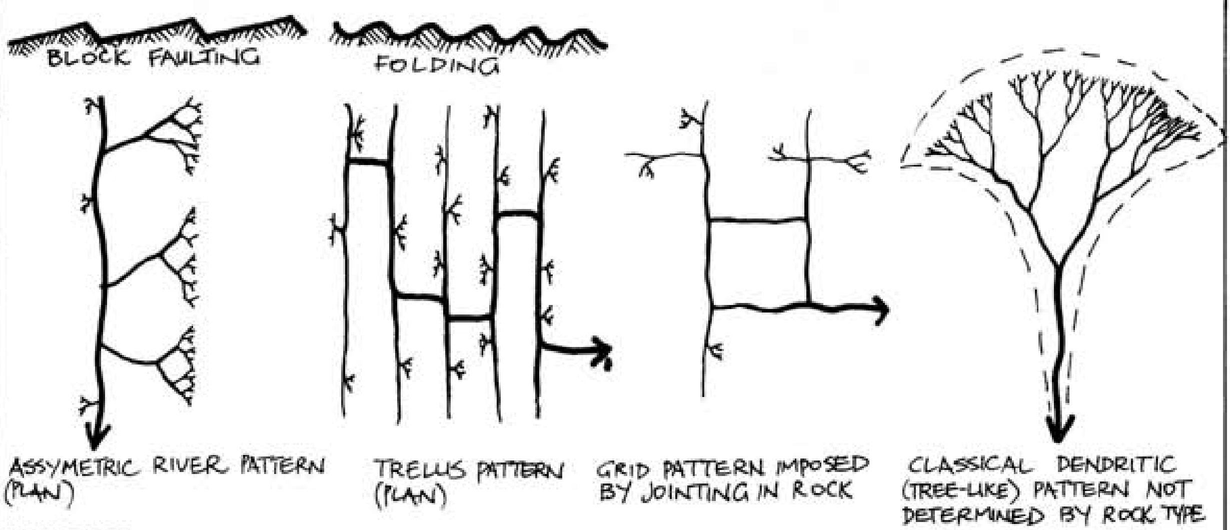


FIGURE 4.24
STREAM PATTERNS
Although the plan patterns of rivers are often decided by the physical structures of landscape, the *orders of size* and branches are comparable to the dendritic pattern.

free-swimming but very active fish of high oxygen demand; these may not live in the still water of higher order streams and low oxygen levels. Thus, we see that gaseous exchange is affected by turbulent flow, and that this in turn determines the life forms in these areas (Vogel, 1981).

In the lower stream or estuaries, we get weak swimmers, less streamlined shapes, flat fish such as flounders, bulky molluscs, jellyfish in quiet areas and lower oxygen levels. We can list many of these life changes which are coincidental with changes in stream order, so we see that the order of streams is very much connected to the behaviour of the water, the landscape, and the shape of life forms in the watershed. Branching of pathways therefore changes species, behaviour, flow, and rates of exchange of nutrients or materials carried by the stream. When we examine a tree, we find that birds and insects are also confined to, or modified to suit, the orders of branching.

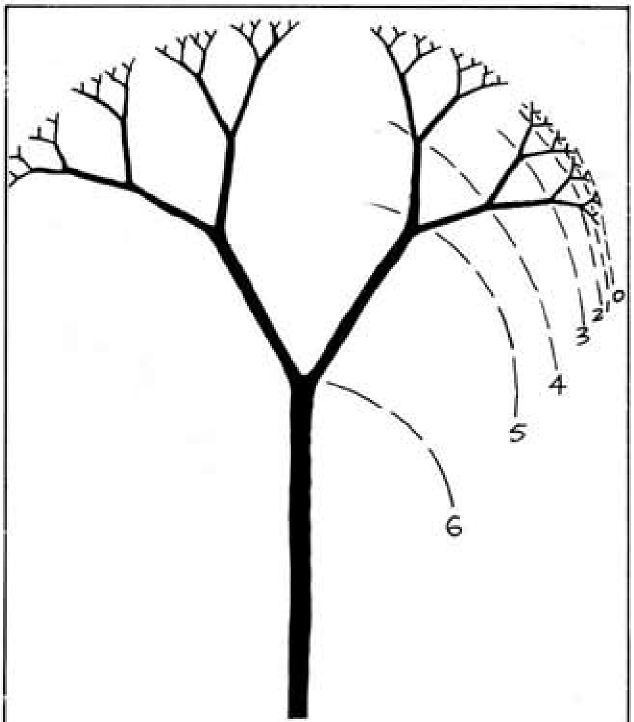


FIGURE 4.25
DENDRITIC BRANCHING.
A regular "tree" based on the proportion of real rivers. The ogives, or curved lines, can be viewd as pulses of growth, waves approaching the viscous "shoreline" of the leaves or (in the case of rivers) the slow seepage of upland rills. Here, seven orders of branches exist; more orders become difficult to develop towards the diffusion surface, where viscous flow slows the movement of fluids.

4.17
ORDERS AND DIMENSIONS

It is in the order of branching (as in our river) that we can gain insight into the order of orders, and the functions of orders. At each point of branching (or size and volume change) everything else changes, from pressures, flows, velocities, and gaseous exchange, to the life forms that associate with the specific size of

TABLE 4.1:
STREAM ORDERS AND SOME RATIOS.

A Folk Name	B Stream Order	C Number of Channels in the Order	D Ratio of bifurcation/	E A. Length Channels branching	F Ratio of Length (km)
Sheet Flow	0	-		-	
			-		-
Rill	1	308		0.28	
			x 3.5		x 2.0
Runnel	2	87		0.56	
			x 3.3		x 2.0
Creek	3	26		1.12	
			x 3.3		x 2.3
Stream	4	8		2.56	
			x 2.7		x 2.2
River	5	3		5.76	
			x 3.0		-
Estuary	6	1		-	
Average			(≈3.0)		(≈2.0)

(Modified after Tweadie, *Water and the World*, Thomas Nelson, Australia, 1975.)
(Arrows indicate ascending orders by factor of increase)

branches. This is how we make sense of the fish species in streams, and the bird species in a tree. Each has its place in a set or order of branches, on the bark of stems, or the leaf laminae of the tree.

This order, or size-function change, produces physical, social, and organic series. Not only species change with order, but so does behaviour. We cannot get a riot of one person, and fewer than 15 rarely clap to applaud as an audience. When we therefore come to *construct* hierarchies, the rules of order should guide us.

An array of orders is observed in a wide range of phenomena such as human settlement size, numbers in social hierarchies, trophic levels (food pyramids), and the size of animals in allied zoological families. The size of the factor itself (times 3 for river branches) changes with the dimensions of the system (times 10 for trophic pyramids). Physical entities from protons to universes display such order, with a consequent increase in the ratio, dimensions, and behaviours associated with size change (giant and dwarf stars behave very differently).

As designers, we need to study and apply branching patterns to roads or trails, and to be aware of the stable orders of such things as human settlements, or we may be in conflict both with orderly flow (can we increase the size of a highway and not alter *all* roads?), with settlement size (villages are conservative at about the 1000–people order, and unstable much below or above that number), with sequences of dam spillways, and even with the numbers of people admitted to functional hierarchies where information is passed in both directions. We can build appropriate or inappropriate systems by choosing particular orders, but we do better to study and apply *appropriate* and stable size and factor classes for specific constructs. For example, in designing a village, we should study the orders of size of settlements, and choose one of these. This decides the number and types of services and the occupations needed, which in turn decides the space and types of shops and offices for a village of that size, and the access network needed.

In human systems, we have confused the order of hierarchical function with status and power, as though a tree stem were less important than the leaves in total. We have made "higher" mean desirable, as though the fingers were less to be desired than the palm of the hand. What we should recognise is that each part needs the other, and that none functions without the others. When we remove a dominant animal from a behavioural hierarchy, another is created from lower orders. When we remove subordinates, others are created from within the dominants. So it is with streams.

Thus, we can see how rivers change their whole regime if we alter one aspect. We should also see that water is *of the whole*, not to be thought of in terms of its parts. Thus we refute the concept of *status* and assert that of *function*. It is not what you *are*; it is what you *do* in relation to the society you choose to live in. We need each other, and it is a reciprocal need wherever we have a function in relation to each other.

4.18

CLASSIFICATION OF EVENTS

All events are susceptible to classification over a variety of characteristics, and as, for example, clouds and galaxies have their pattern–names, so do many other phenomena. Some basic ways to classify events in a unified system are:

A. NATURE.

A1. <u>Explosive</u>, disintegration, erosion, impact, percussion.

A2. <u>Growth</u>, integration, construction, translation.

A3. <u>Conceptual</u>, idea, creative thought, insight.

B. STAGE.

B1. <u>Potential</u> only (ungerminated seed, unexplored idea, unexploded bomb).

B2. <u>In process</u> of evolution.

B3. <u>Completed</u> (growth and expansion ceased), articulated.

B4. <u>Decaying</u> (disintegrative, replaced or invaded by new events) disarticulated.

C. DIMENSION.

C1. <u>One</u> (linear phenomena), curves.

C2. <u>Two</u> (surface phenomena), tessellae, dendrites.

C3. <u>Three</u> (solid phenomena), trees.

C4. <u>Four</u> (moving solid phenomena), includes the time dimension.

C5. <u>More</u> (conceptual phenomena) models of particles or forces, states of energy.

D. LOCATION

D1. <u>Generating</u> across equi–potential surfaces (storms at sea).

D2. <u>Within</u> media (weather "frontal" systems).

D3. <u>Through</u> surfaces at 90° or so (trees).

D4. <u>Englobements</u> (some explosions and organisms).

D5. <u>An idea</u>, located out of normal dimensions of space–time.

By extending and applying these categories, all events can be given short annotations, e.g.:

- A sapling is: A2, B2, C3, D3.
- A falling bomb is: A1, B1, C4, D2.

4.19

TIME AND RELATIVITY IN THE MODEL

As we see the seed as the origin of the tree, so we can broaden our view, and our dimensions, and view the tree as the current time–focus of its own genealogy.

Before it in time lie its ancestors, and after it its progeny. It lies on the plane between past and future, and (like the seed) determines by its expression the forms of both, and is in turn determined by them. Just as the stem of the tree now encapsulates its history as smaller and smaller growth rings, so universal time encapsulates the tree in its own evolutionary history. This is difficult to portray, and has more dimensions that we can illustrate on a page. It is the basis of the Buddhist belief that all time is enfolded or *implicate* in the present, and that current events are part of a total sequence, all of which are enfolded in the present tree as ancestors, or siblings.

As we read this, we stand in the plane of the present; we are the sum of all our ancestors, and the origin of all our descendants. In terms of our model, we are at an ever-changing origin, located on the boundary of past and future. As well, we are spinning with the earth, spiralling with the galaxy, and expanding or contracting with the universe. As origins, we are on the move in time and space, and all these movements have a characteristic pulse rate.

Our bodies contain the potential for future generations, awaiting the events of pairing to create their own future events. Like a seed origin buried in the tree stem, we are buried in the stem of our siblings in a genealogy, whose branches thrive, die, and put forth new shoots and roots over time.

This is the case with all origins; they can all, even if ancient, be located in this matrix. If we know how to reconstruct the tree, we can find the place of the seed and vice versa. All rivers, erosion cells, and all glaciers originated, therefore, at the *central* stem of their courses, and built their pattern both ways along the kinetic gradient of their flow. Thus, in terms of the time dimension we see the present as the ORIGIN of both the past and the future (located as it is in the centre of our pattern).

Designers can move sideways in the waves of time (as a surfer on a wave-front), transporting seed from continent to continent, permitting natural or induced hybrid palms and legumes to weave an alternative future. Mankind is an active translator of life, and, of course, of death.

In all core models, including our own genealogy, the point where all the important action takes place is through the point of origin, which is always in the present. How we behave *now* may determine not only the future, but the past (and all time). Think of that, and realise that you are really where it's at, no matter when you are! I find great personal meaning in the Australian aboriginal life ethic, and little enough comfort in any pie-in-the-sky. If it *is* my actions which determine the sky, I want it to be full of life, and I choose to believe that I am part of all that action, with my own job to do in this life form, and other jobs to do in other phases.

4.20
THE WORLD WE LIVE IN AS A TESSELLATION OF EVENTS

I live in the crater of an ancient volcano, the caldera of which is in part eroded by the sea. Trees rise from the soils, and birds nest in them. From the seeds and eggs in the trees arise new life forms. Great wind spirals sweep in from the west with almost weekly regularity, bearing the fractal forms of turbulent clouds and causing, in autumn and mid-summer, lightning and thunder.

On this peninsula, the terminal volcanic core stands fast, refracting waves to either side, and creating a pinched neck of sand which joins us to the mainland. The hills are stepped by successive sea-level changes, and record the pulses of long-term cycles and successions. Day follows night, and life follows death follows life.

All of these phenomena are a unity of patterns long repeated and based on one master pattern, each one preparing for new evolutions and dissolutions. It is the number and complexity of such cycles that give us life opportunities, and life is the only integrative force in this part of the universe. Let us respect and preserve it.

An understanding (even a partial understanding) of the underlying patterns that link all phenomena creates a powerful abstract tool for designers. At any point in the design process, appropriate patterning can assist the achievement of a sustainable yield from flows, growth forms, or information flux. Patterns imposed on constructs in domestic or village assemblies can result in energy savings, and satisfactory aesthetics and function, while sustaining those organisms inhabiting the designed habitat.

Patterning is the way we frame our designs, the template into which we fit the information, entities, and objects assembled from observation, map overlays, the analytic divination of connections, and the selection of specific materials and technologies. It is this patterning that permits our elements to flow and function in beneficial relationships. The pattern *is* design, and design is the subject of permaculture.

Bohm (1980) urges us to go beyond regarding ourselves as interactive with each other and the environment, and to see all things as "projections of a single totality". As we experience this totality, incorporate new information, and develop our consciousness, we ourselves are fundamentally changed. "To fail to take this into account must inevitably lead one to a serious and sustained confusion in all that one does." The word "implicate" in the title of Bohm's work comes from the Latin "enfolded", and when we separate individuals, effects, or disciplines from this enfolded order, we must recognise only that we have part of the unknowable totality, not the truth itself. There are no opposites, just phases of the one phenomena.

For myself, and possibly for you if you take up the study of patterns, the contemplation of the forms of life and flow has enabled me to bring to consciousness the unity of all things, and the enfolded nature of Nature. In the matter of genealogy we can become conscious of ourselves in the time and pattern stream, and it is startling to realise that (as origin) we "determine", or rather define and are defined by, our ancestry as much as we define and are defined by our descent. We do not doubt our physical connection to either ancestry or descent. It is the sense of "all are present here" that is revealed by pattern: to be encapsulated in, and a pervading part of, a personal genealogical pattern which is itself a result of a pattern of innumerable variables.

Patterns tell us that all is streams, all particles, all waves. Each defines the other. It tells us that all is one plan. Although we find it difficult to see pattern in all the plan, it is there. We are the universe attempting to define its processes. A Kalahari bushman would say we are the dreams of a dreamer. What I feel we can never define is substance (except *as* process; this is all it may be). We can only know a few local patterns, and thus have some weak predictive capacity. It is the pattern that our local patterns cannot know that will surprise us, the strike of cosmic lightning from an unguessed source or stress.

Finally, pattern understanding can only contribute to the current and continuing evolution of new world views based on the essential one-ness of all phenomena. Lovelock (1979) has perhaps best expressed that combination of scientific insights and older tribal beliefs which assert the interdependence of animate and inanimate events. The universe, and this earth, behave as self-regulating and self- generated constructs, very much akin to a single organism or a thought process.

The conditions which make life possible are balanced about such fine tolerances that it seems close to certainty that many processes exist just to preserve this equilibrium in its dynamic stability.

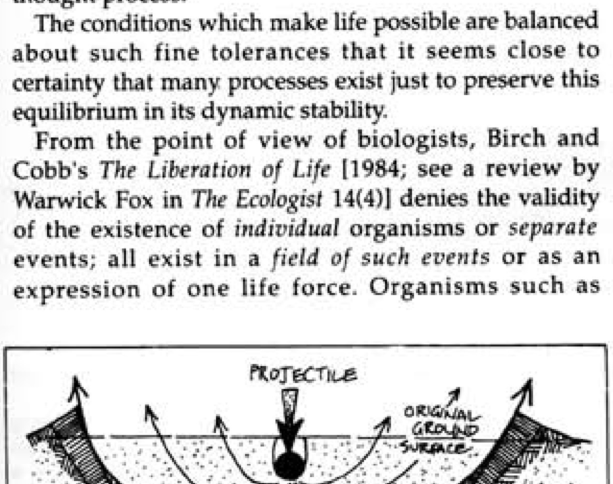
From the point of view of biologists, Birch and Cobb's *The Liberation of Life* [1984; see a review by Warwick Fox in *The Ecologist* 14(4)] denies the validity of the existence of *individual* organisms or *separate* events; all exist in a *field of such events* or as an expression of one life force. Organisms such as ourselves exist only as an inseparable part of our event environments, and are in continual process of exchange with the animate and inanimate entities that surround us. We are acted upon and acting, created and creating, shaped and shaping. Fox asserts, as I have here, that "we must view the cosmos as an infinite complex of interrelated events"; all things "are in actuality enduring societies of events."

Theoretical physicists (Capra, 1976) contribute to such world views, all of which are in conflict with the current ethics that govern political, educational, and economic systems, but all of which are contributing to an increasing effort to unify and cooperate in a common ethic of earth-care, without which we have no meaning to the universe.

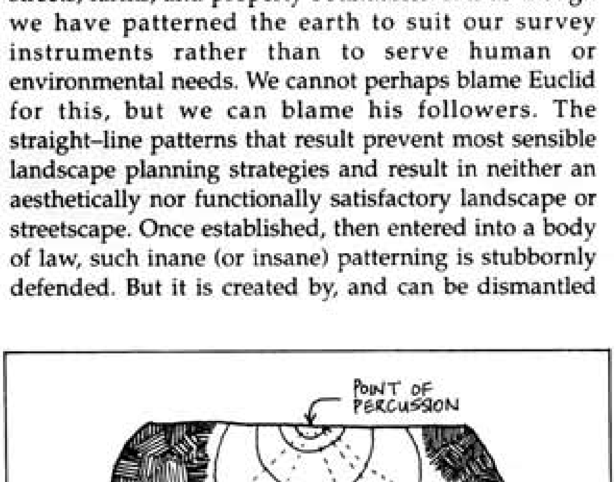
4.21
INTRODUCTION TO PATTERN APPLICATIONS

There are two aspects to patterning: the perception of the patterns that already exist and how these function, and the imposition of pattern on sites in order to achieve specific ends. Both are skills of sophisticated design, and may result in specific strategies, the harmonious resolution of problems, or work to produce a local resource. Given that we have absorbed some of the information inherent in the general pattern model, we need some examples of how such patterning has been applied in real-life situations.

A bird's-eye view of centralised and disempowered societies will reveal a strictly rectilinear network of streets, farms, and property boundaries. It is as though we have patterned the earth to suit our survey instruments rather than to serve human or environmental needs. We cannot perhaps blame Euclid for this, but we can blame his followers. The straight-line patterns that result prevent most sensible landscape planning strategies and result in neither an aesthetically nor functionally satisfactory landscape or streetscape. Once established, then entered into a body of law, such inane (or insane) patterning is stubbornly defended. But it is created by, and can be dismantled



Meteor impact crater or "drip splash" forms resemble volcanic calderas.



Percussion and pressure flaking produce typical patterns in obsidian or chert tools shaped by stone workers.

by, people.

A far more sensible approach was developed by Hawaiian villagers, who took natural ridgelines as their boundaries. As the area was contained in one water catchment, they thus achieved very stable and resource-rich landscapes reaching from dense cloud-forests to the outer reefs of their islands. The nature of conic and radial volcanic landscapes with their radial water lines suits such a method of land division. It is also possible for a whole valley of people to maintain a clean catchment, store and divert mid-slope water resources for their needs, catch any lost nutrients in shallow ocean enclosures (converting first to algae, then to crabs and fish), and thus to preserve the offshore reef area and the marine environment. Zulus and American Indians adopt the circular or zonal modes in their plains settlements.

Such models can be studied and adopted by future (**bioregional**) societies as sane and caring people become the majority in their region, and set about the task of landscape rehabilitation. Sensible land division is a long-delayed but essential precursor to a stable society.

4.22
THE TRIBAL USES OF PATTERNING

As I travel about the world, I find tribal peoples using an enormous variety of traditional patterns. These decorate weapons, houses, skin, and woven textiles or

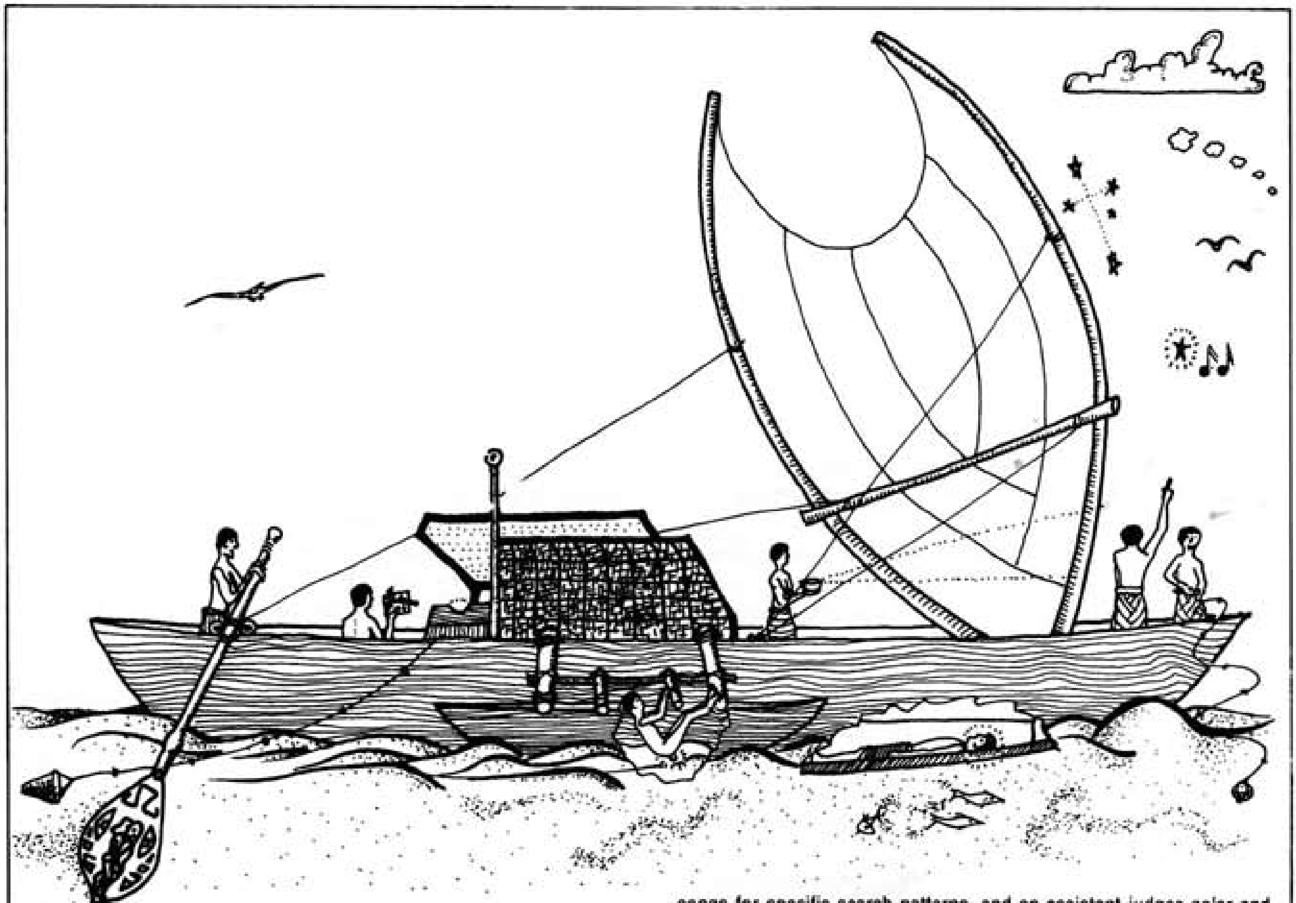


FIGURE 4.26
TRADITIONAL NAVIGATION RELIES ON PATTERN RECOGNITION.

• The helmsman sings to time the log line, and feels for current deflections through his steering oar. He or she sings to record the stages of the journey and the "rivers" (currents) of the sea.

• Lookouts note star patterns, bird flight, cloud trains, or light refracted from coastal lagoons. Water speed is recorded by a knotted float line.

• A skilled listener in a "black box" near the keel listens to wave refraction from the hull, predicts storms or islands from wave periods timed by chants.

• A navigator consults a voyage "chart" of sticks and cowries representing the interaction of phenomena and sings the navigation songs for specific search patterns, and an assistant judges solar and star elevations (latitude) via a water level.

• At night, the glow of life forms in deep sea trenches is awaited (the "lightning" from the deeps"), bird song and echoes from headlands are listened for, and the phosphorescent glow of the forests ashore is awaited.

• An experienced man lowers his testicular sac into the sea to accurately guage water mass temperature.

• The wind carries a variety of scents from forests, rock lichen, bird colonies, and fish schools; all are recorded.

• A net catches indicator organisms related to the water mass, and near shores a "lead line", or depth line, is used to find banks and sample bottom fauna picked up in soft grease.

• A crystal of calcite may be used to predict rain or to find the sun on overcast days by polarisation of light—"the lodestone" of navigators.

baskets. Many patterns have sophisticated meaning, and almost all have a series of songs or chants associated with them. Tribal art, including the forms of Celtic and ancient engraving have a pattern complexity that may have had important meanings to their peoples. We may call such people illiterate only if we ignore their patterns, songs and dances as a valid literature and as an accurate recording system.

Having evolved number and alphabetical symbols, we have abandoned pattern learning and recording in our education. I believe this to be a gross error, because simple patterns link so many phenomena that the learning of even one significant pattern, such as the model elaborated on in this chapter, is very like learning an underlying principle, which is always applicable to specific data and situations.

The Maori of New Zealand use tattoo and carved patterns to record and recall genealogical and saga information. Polynesians used pattern maps, which lacked scale, cartographic details, and trigonometric measures, but nevertheless sufficed to find 200–2,000 island specks in the vastness of the Pacific! Such maps are linked to star sets and ocean currents, and indicate wave interference patterns; they are made of sticks, flexed strips, cowries, and song cycles (**Figure 4.26**).

Pitjantjatjara people of Australia sing over sand patterns (**Figure 4.27**), and are able to "sing" strangers to a single stone in an apparently featureless desert. Many of their designs accurately reflect the lobular shapes and elaborate micro-elevations of the desert, which are nevertheless richly embroidered by changes in vegetation, and are richly portrayed in what (to Westerners) appears as abstract art. Some pattern mosaics are that of fire, pollen, or the flowering stages of a single plant, others are of rain tracks and cloud streets, and yet others involve hunting, saga, or climatic data.

Children of many tribes are taught hundreds of simple chants, the words of which hide deeper, secondary meanings about medicinal, sacred, or navigational knowledge. All this becomes meaningful when the initiate is given the decoding system, or finds it by personal revelation (intuition). A pattern map may have little meaning without its song keys to unlock that meaning. Initiation can also unlock mnemonic patterns for those who have a first clue as to meaning.

Dances, involving muscular learning and memory, coupled with chants, can carry accurate long-term messages, saga details, and planting knowledge. Many dances and chants are in fact evolved from work and travel movements. Even more interesting are the dance-imitations of other animal species, which in fact interpret for people the postural meanings of these species, although in a non-verbal and universally-transmittable way. We may scarcely be aware that many of our formal attitudes of prayer and submission are basic imitations of primate postures, for the most part taken from other species. Even the chair enables us (as it did the Egyptians) to maintain the postures of

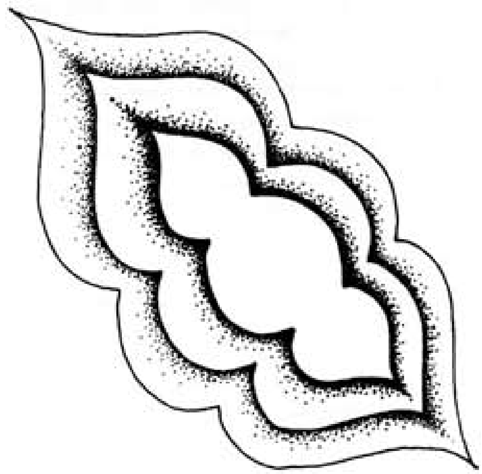


FIGURE 4. 27
SAND PATTERN MAPS (PITJANTJATJARA).
A song map of the Pitjitjantjara women. Such forms closely resemble desert claypans if the long axis is regarded as a flow axis, and the zones as lobular vegetation.

baboons, and baboons were revered as gods and embalmed by the Egyptian chair-makers. We can remember hundreds of songs, postures, and chants, but little of prose and even less of tabulated data.

Anne Cameron (*Daughters of Copper Woman*, Vancouver Press, 1981) writes of song navigation in the Nootka Indians of British Columbia: "There was a song for goin' to China, and a song for goin' to Japan, a song for the big island and a song for the smaller one. All she (the navigator) had to know was the song and she knew where she was..."

The navigation songs of the women on canoe voyages record "the streams and creeks of the sea"—the ocean currents, headlands and bays, star constellations, and "ceremonies of ecstatic revelation". From California to the Aleutians, the sea currents were fairly constant in both speed and direction, and assisted the canoes. The steerswomen used the (very accurate) rhythm of the song duration to time both the current speed and the boat speed through the water. Current speed would be (I presume) timed between headlands, and boat speed against a log or float in the water. The song duration was, in fact, an accurate timing mechanism, as it can be for any of us today.

Song stanzas are highly accurate *timers*, accurate over quite long periods of time, and of course reproducible at any time. The song *content* was a record of the observations from prior voyages, and no doubt was open to receive new data.

People who can call the deer (Paiute wise men), the dolphin (Gilbert Islanders), the kangaroo (tribal Tasmanians) and other species to come and present themselves for death had profound behavioural, interspecific, "pulser" pattern-understanding. Just as the Eskimo navigated, in fog, by listening to the quail dialects specific to certain headlands, we can achieve similar insights if our ear for bird dialect is trained, so that song and postural signals from other species make a rich encyclopaedia of a world that is unnoticed by those who lack pattern knowledge. People who can kill by inducing fibrillation in heart nerves have a practical insight into pulser stress induction; many tribespeople can induce such behaviour in other animal species, or in people (voodoo or "singing").

The attempts of tribal shamans to foresee the future and to control dreams or visions by sensory deprivation, to read fortunes by smoke, entrails, water, or the movement of serpents, or to study random scatters of bones or pebbles are not more peculiar than our efforts to do the same by the study of the distribution of groups of measures or the writhing of lines on computer screens. By subjecting ourselves to isolation, danger, and stress, we may pass across the folds of time and scan present and future while we maintain these "absent" states, as described by Dunn (1921) in his *Experiment with Time*, and as related by participants in the sun dances of the Shoshone nation. As we drown, or fall from cliffs, our lives "pass before our eyes" (we can see the past and future).

We need to think more on these older ways of imparting useful or traditional information, and of keeping account of phenomena so that *they are available to all people*. Number and alphabet alone will not do this. Pattern, song, and dance may be of great assistance to our education, and of great relevance to our life; they are the easiest of things to accurately reproduce.

Apparently simple patterns may encode complex information. There may be no better example than that of the Anasazi spiral, with 19 intercepts on its "horizon" "horizon" line (**Figure 4.28**). This apparently simple spiral form is inscribed on a rock surface near the top of a mesa in desert country in the southwest USA. Three rock slabs have been carefully balanced and shaped, as gnomons which cast moon-shadows or (by their curvature) direct *vertical* daggers of sunlight to the points of the spiral. The 19 points at which the spiral intersects the horizontal axis are those at which the shadow of the moon is cast by a gnomon on the spiral, and indicate the moon elevation or 19-year (actually 18.6) cycle caused by the sway of the earth's axis.

Thus, one simple spiral records lunar and solar cycles for the regulation of planting, the timing of ceremonies, and (as modern science has just realised), the prediction of the 19-year (18.6 year) cycle of drought and flood. A very simple pattern encodement thus represents a practical long-term calendar for all people who live nearby. The Anasazi culture is extinct, and only a persistent investigation by Anna Soaer (an artist with *intuitive* observational skills) has revealed the significance of this arrangement. Scientists have often doubted the capacity of tribal peoples to pattern such long-term and complex events, which in terms of our clumsy alphabetical and numerical symbols are not

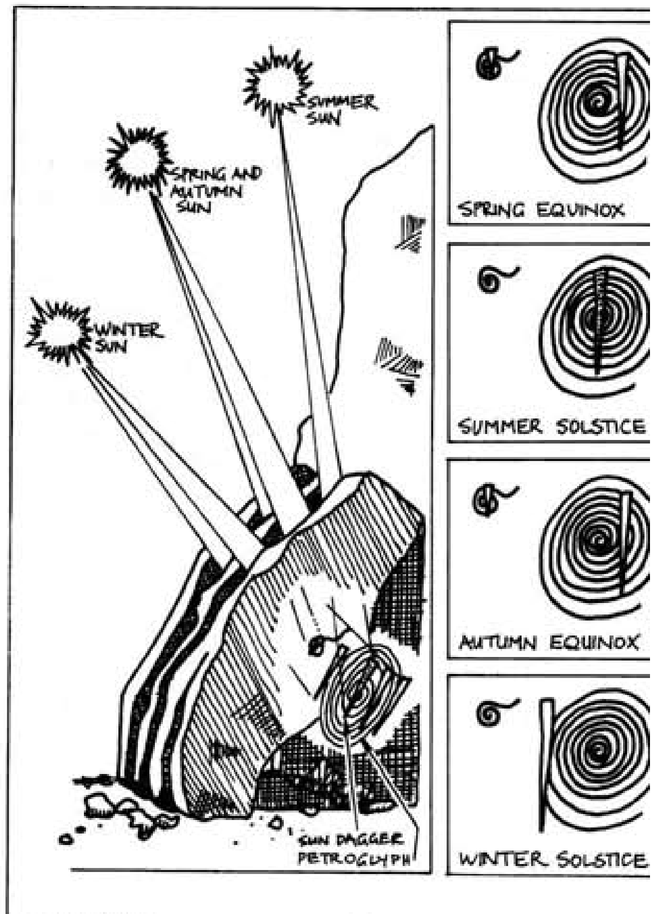
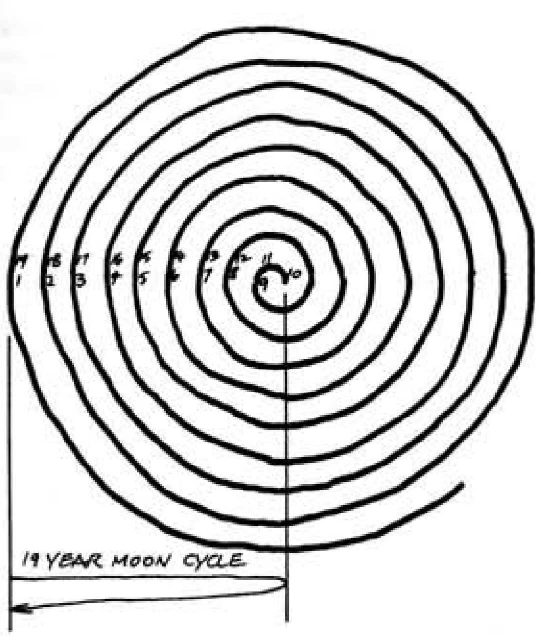


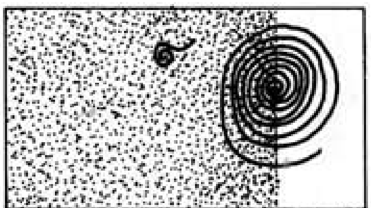
FIGURE 4.28
A petroglyph (rock carving) of the Anastasi Indians (North America) forms a long-term calendar of sun and moon cycles.

only forgettable, but would take a small library to encode. The knowledge so presented is available to very few (ABC TV Science programme, Australia, 20th January '84). However, wherever tribes remain intact, there are many such sophisticated pattern-meanings still intact, all as complex and information-dense.

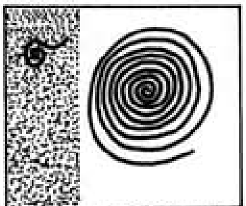
In the complex of time-concepts evolved by Australian Aborigines, only one (and the least important) is the linear concept that we use to govern our life and time. Of far greater everyday use was phenomenological (or phenological) time; the time as given not by clocks, but by the life-phenomena of flowers, birds, and weather. An example from real life is that of an old Pitjatjantjara woman who pointed out a small desert flower coming into bloom. She told me that the dingoes, in the ranges of hills far to the north, were now rearing pups, and that it was time for their group to leave for the hills to collect these pups. Thousands of such relationships are known to tribal peoples. Some such signals may not occur in 100 or 500 years (like the flowering of a bamboo), but when it does occur, special actions and ceremonies are indicated, and linked phenomena are known.

Finally, in tribal society, one is not wise by years, but by degree of revelation. Those who understand and





FULL MOON SHADOW AT 'MINIMUM' RISING POINT CAST BY 3RD SLAB.



FULL MOON SHADOW AT 'MAXIMUM' RISING POINT CAST BY THIRD SLAB.

embody advanced knowledge are the most intuitive, and therefore most entitled to special veneration. Such knowledge is almost invariably based on pattern understanding, and is independent of sex or even age, so that one is "aged" by degree of revelation, not time spent in living (there are some very unrevealed "elders" in the world!).

4.23

THE MNEMONICS OF MEANING

Buddhists remind themselves of the pattern of **events** with their oft-repeated chant "Om mani padme hum"; pronounced "Aum ma–ni pay–may hung" by Tibetans and Nepalese, and meaning:

Om: the jewel in the lotus : hum

om · ma · ni · pay · may · hung

As Peter Matthiessen explains it (*The Snow Leopard*, Picador, 1980):

Aum (signing on) is the awakening or beginning harmonic, the sound of all stillness and the sounds of all time; it is the fundamental harmonic that recalls to us the universe itself.

Ma–ni: The unchanging essence or diamantine core of all phenomena; the truth, represented as a diamond, jewel, or thunderbolt. It is sometimes represented in paintings as a blue orb or a radiant jewel, and sometimes as a source of lightning or fire.

Pay–may: "Enfolded in the heart of the lotus" (mani enfolded). The visible and everyday unfolding of events, petals, or patterns thus revealing the essential unchanged core (mani) to our understanding. The core itself, or the realisation of it, is *nirvana* (the ideal state of Buddhism). The lotus represents the implicate order of tessellated and annidated events, and the process of unfolding the passage of time to successive revelations. At the core is unchanging understanding.

Hung (signing off): "It is here, *now*." A declamation of belief of the chanter in the words. It also prefaces the "Om" or beginning of the new chant cycle, although in a long sequence of such short chants, all words follow their predecessors. This is the reminder mnemonic of implicate time; all events are present *now*, and forever repeated in their form.

DORJE, or Dorje–chang, is the Tibetan Buddha–figure who holds the *dorje* (thunderbolt), represented as a radiant stone which symbolises cosmic energy. Dorje is "the primordial Buddha of Tibet", who began the great succession of current and past reincarnations. His colour is blue, for eternity, and he may carry a bell to signify the voiceless wisdom of the inanimate, or the sound of the void.

Dorje is an alter ego of Thor of the Norsemen, Durga of the Hindu, and of thunderbolts and "thunderers" of other tribal peoples. The *mani* or stone of Thor was Mjollnir, his hammer, from which derives Mjollnirstaun, and (eventually) Mollison (by way of invasions into Scotland, and migrations). Thus, even our own names may remind us of the essential oneness of the events and beliefs around us.

We can choose from tribal chants, arts, and folk decoration many such mnemonic patterns, which in their evolution over the ages express very much the same world concept as does modern physics and biology. Such thoughtful and vivid beliefs come close to realising the actual nature of the observed events around us, and are derived from a contemplation of such events, indicating a way of life and a philo-sophy rather than a dogma or set of measures.

Beliefs so evolved precede, and transcend, the emphasis on the individual, or the division of life into disciplines and categories. When we search for the roots of belief, or more specifically *meaning*, we come again and again to the one–ness underlying science, word, song, art, and pattern: "The jewel in the heart of the lotus".

Thus we see that many world beliefs share an essential core, but we also see the drift from such nature-based and essentially universal systems towards personalised or humanoid gods, dogma, and fanaticism, and to symbols without meaning or use in our lives, or to our understanding of life. Many other world-concepts based on the analogies of rainbows, serpents, and song cycles relate to aspects of the integrated world view, and are found in Amerindian and Australian tribal cultures.

4.24

PATTERNS OF SOCIETY

We can pattern the behavior of human and other social animals to represent aspects of their society. A set of such patterns, derived from studies I and my students made in Tasmania from 1969 to 1974 are illustrated in **Figure 4.29**. The central pattern represents the orders or castes of occupational level (status) in its long axis. There are seldom more than seven major occupational levels even in such rigorously-stratified hierarchies as the army. The width of the **Figure 4.29** represents the numbers of people at each level, and for this configuration we summed the numbers of people in several organisations (to sample some 35,000 people), including the local army, a multinational company, some churches and many small businesses.

Within the general "boat" pattern form so evolved, I have marked some arrows to represent genetic streaming (by marriage or sexual congress); important classes of occupation are:

1. LOW OCCUPATIONAL (RESOURCE) AREA—MANUAL AND UNSKILLED URBAN:
Characteristics are a general dearth of material resources, low status, part-time occupations, and a remarkable preponderance of male births and survived male children (about 140 males per 100 females). Large families. Serial polyandry is common or acceptable.

2. THE CENTRAL OR MOST POPULATED LEVEL; THE "MIDDLE CLASS":
Adequate resources, nine-to-five jobs, some job tenure, and a "normal" birth ratio of 104 males per 100 females. Mixed white collar and skilled technical workers, average family sizes. Monogamy is an ideal, but is often expressed as serial monogamy.

3. THE UPPER LEVELS:
Few people, extensive resources, flexible and often self-set times, and a high proportion of female children (about 100 females to 70 males or less); urban professionals or managers would typify the group. Small families, effective polygyny via concubines or mistresses.

4. VERY HIGH LEVELS:
Executive directors and landed nobility. Variable family sizes but a preponderance of female children (as per 3. above), and a habit of lateral intermarriage for economic alliances, facilitated by exclusive schools and resorts.

The imbalance of the sex ratios in these strata ensures a genetic turnover or diffusion between classes; a streaming of genetic materials between levels over generations.

4.25

THE ARTS IN THE SERVICE OF LIFE

Art, in the forms of song, dance, and sculptural or painted objects, or designs, is an ancient preoccupation of all peoples. There is little doubt that most (if not all) tribal art is intended for quite specific ends; much of

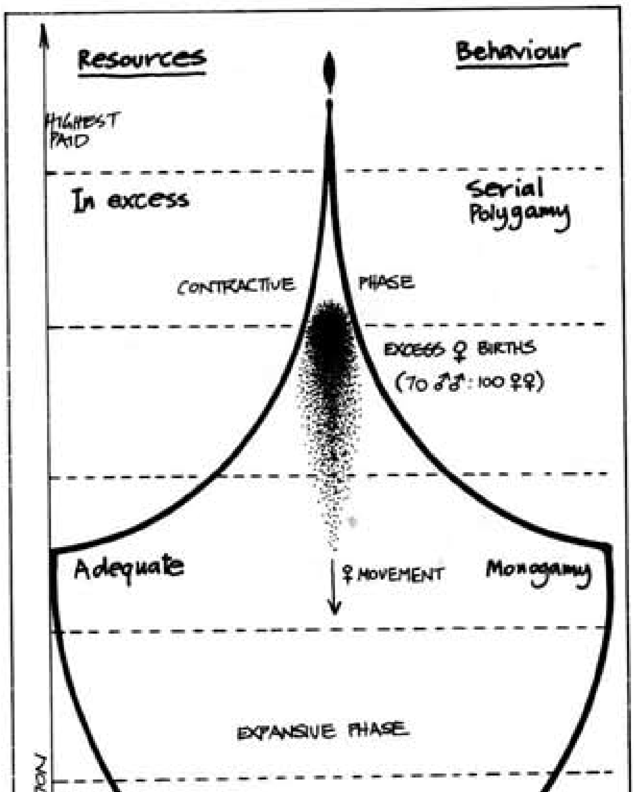


FIGURE 4.29
BEHAVIOUR PATTERNS IN SOCIETY.
The form of social hierachy based on occupational status. Note the over production of males (as a primary sex ratio) at the lower resource level, thus marital habits are based on resources and sex ratios. Width indicates number of people at each level. (n = 35,000 Tasmania, 1975).

tribal art is a public and ever-renewed mnemonic, or memory-aid. Apparently simple spiral or linear designs can combine thousands of bits of information in a single, deceptively simple pattern. The decorative function is incidental to the educational and therefore sacred information function in such patterns. "Decoration" is the trivial aspect of such art.

Much of modern art is individualistic and decorative; some "motif" art is plagiarised from ancient origins, but no longer has an educational or sacred function. Entertainment and decoration *is* a valid and important function of the arts, but it is a minor or incidental function. Social comment is a common art form in theatre and song, and spirited dances and songs are cheering or uplifting. But I know of no meaningful songs or patterns in my own "monoculture", based as it is on the jingles of advertisements and purely decorative and trivial patterns of art, and on education divorced from relevant long-term observations of the natural world.

The induction of moods and the record of ephemera are not the primary purposes of sacred or tribal art, which is carefully assembled to assist the folk records of the function and history of their society. Some modern sculptural forms, such as the "Flowform" systems of the Virbella Institute, Emerson College, Kent, UK (**Figure 4.33**) are modelled on older Roman water cascades, and serve both an aesthetic and a water-oxygenation function, assisting water purification. This is a small step towards applied art as patterning in everyday use, as are some engineering designs. We could well reintroduce or evolve pattern education, which gives *every* member of society access to profound concepts or specific knowledge.

Art belongs to, and relates to, people. It is not a way to waste energy on resources for the few. Sacred calendars melted down to bullion or objets d'art are a degradation of generations of human effort and knowledge, and the sacred art of tribal peoples hidden in museum storerooms are a form of cultural genocide, removing knowledge from its context, and trivialising objects to decorations or loot.

Human information, as a tribal art form, is most frequently debased and destroyed less for monetary gain than for the replacement of *public* information by an exotic, secretive, irrelevant and basically uninformed centralised belief system. The fanatic cares not what is destroyed if it empowers the repressive hierarchy that is then imposed. Most tribal art has been burnt, looted, destroyed, and broken by invading belief systems, destroyed by those seeking secret power rather than open knowledge, or by those who are merely destructive. Book-burning and image-breaking is the reaction of the alienated or intellectually-deprived to the accumulated wisdom of its revelationary ancestors. We most damage ourselves when we destroy information and aids to understanding.

It is a challenge to artists to study and portray knowledge in a compact, memorable, and transmissible form, to research and recreate for common use those surviving art forms which still retain their meaning, and to re-integrate such art with science and with society and its functions and needs. It is a challenge to educators to revive the meaningful geometries, songs, and dances that gave us, and our work, meaning.

4.26
ADDITIONAL PATTERN APPLICATIONS

A sophisticated application of pattern is found in the herb spiral (**Figure 4.30**) which I evolved in 1978 as a kitchen-door design. All the basic culinary herbs can be planted in an ascending spiral of earth on a 2 m wide base, ascending to 1 or 1.3 m high. All herbs planted on the spiral ramp are accessible. The construct itself gives variable aspects and drainage, with sunny

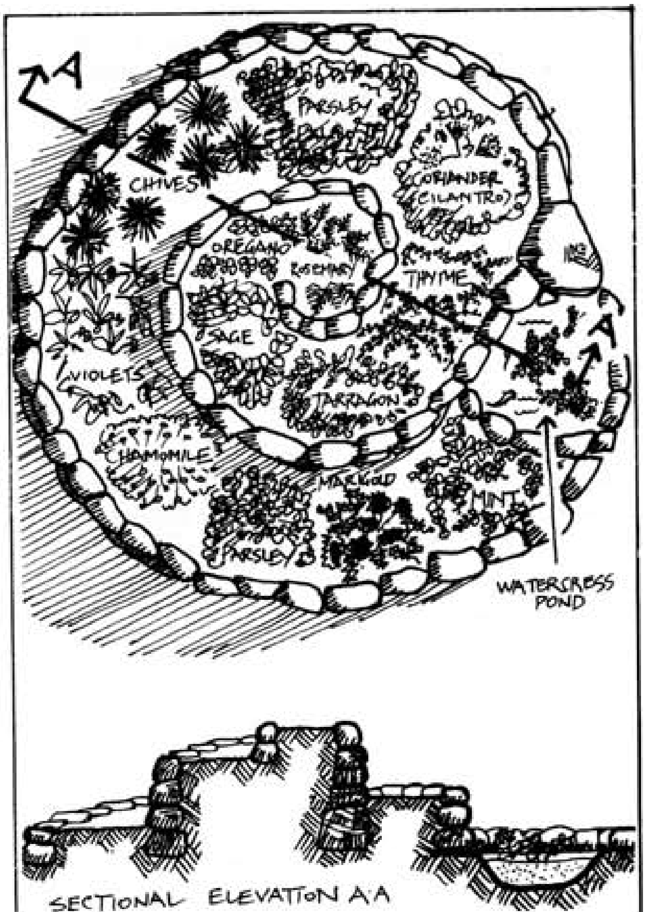


FIGURE 4. 30
HERB SPIRAL.
Pattern applied. A modest 2 m diameter by 1 m high earth spiral accommodates all necessary culinary herbs close to the kitchen door and can be watered with one 2 m sprinkler—a considerable saving in space and water as the ramp and walls exceed 9 m of plant space.

dry sites for oil–rich herbs such as thyme, sage, and rosemary, and moist or shaded sites for green foliage herbs such as mint, parsley, chives, and coriander.

This is a rare three–dimensional earth construct on a small scale, and compactly coils up a linear path or bed of herbs into one mound at the kitchen door, thus making the herbs accessible and convenient to the kitchen itself. If kitchens are not at ground level, roof or balcony gardens can carry pot–herbs in stepped walls, on wall shelves, in window boxes, or as stacks of pots in earth mounds.

Pattern analyses can also be applied to water conservation. For example, a mulch–pit (60 cm wide and deep), surrounded by a planting shelf and spill bank totalling 1.2 m (4 feet) across has a 3.8 m (12 foot) perimeter, but can be efficiently watered with *one* low–pressure sprinkler, whereas a 3.8 m straight row takes *three* such sprinklers.

Another advantage is the central (one–drop) mulch pit, so that the plants eventually overshade the centre to prevent evaporation. Such circle–mulch– grow pits are made 1.8 m (6 feet) across for bananas, and 1.8–3 m (6–10 feet) across for coconuts; all out– produce row crop for about one–third of the water use. A series or set of such gardens greatly reduce the path space and land area needed for home gardens, or orchards of banana and coconut (**Figures 4.31** and **10.26**).

A field application of patterned ground designed to direct flow, and capture materials in flow, is that of flood–plain embankments or tree lines (poplar, willow, tamarack), or both combined. These are very effective pattern impositions on landscape (although all occur naturally as rock dykes or resistant rock strata in the field) that can have several beneficial effects for a household or settlement nearby (**Figure 4.32**).

A more conscious and portable applied pattern set is that of the "Flowform" models being developed at the Virbella Institute by a small group of artist–technicians. Such turbulence basins are apparent in nature as shaped basins in streams flowing over massive sandstones or mudstone rocks. They are even in antiquity modelled in pozzelanic cement by Roman hydrologists. Flowforms are artificial replicates of the rock forms carved by turbulent streams, cast in concrete or fibreglass (**Figure 4.33**).

Stacked in sets below sewage pipe outfalls or above fish ponds at pipe inlets, they efficiently mix air and water by inducing turbulence in flow. Three distinct mixing effects are noticeable; the first a *plunge* or vertical overturn as fluid drops from one basin to another; the second as a figure–8 or lateral flow around the basins themselves; and the third (a fascinating process) as an interaction between these two, as water coursing around the basins deflects the vertical drop flow and switches it from side to side in a regular rhythm.

Within these major turbulence patterns [so clearly portrayed by da Vinci (Popham, A.E., *The Drawings of Leonardo da Vinci*, Jonathan Cape, London, 1946) and further analysed in terms of computer models and catastrophic theory by Chappell (in: *Landform Evolution in Australia*, ANU Press, Canberra 1978) for coastal uprush and backwash turbulence] are distinct vortices and counterflow, overfolds and cusps that further mix air and water at the edges of the basins and in the main flow stream.

Thus, artificial Flowform basins induce aeration, oxidise pollutants, and are themselves aesthetically pleasing and instructive hydrological pattern–models of naturally–occuring constructs. They have practical use in the primary treatment of sewage and organically polluted waters, and in the oxygenation of ponds for aquatic species production. Models of this type are the result of a long evolution beginning with wonder, sketches, analysis, observations, and then proceeding via constructed hydrological basins to practical applications over a wide variety of sites. In nature and in the Flowform system, the basins can be elongate, truncate, symmetrical, asymmetical, stepped in line, stacked like ladders, or spiralled to conserve space.

4.27 REFERENCES AND FURTHER READING

Alexander, Christopher *et al*, *A Pattern Language*, Oxford University Press, 1977.
(Instances successful design strategies for towns, buildings)

Bascom, Willard, *Waves and Beaches*, Anchor Books, New York, 1980.

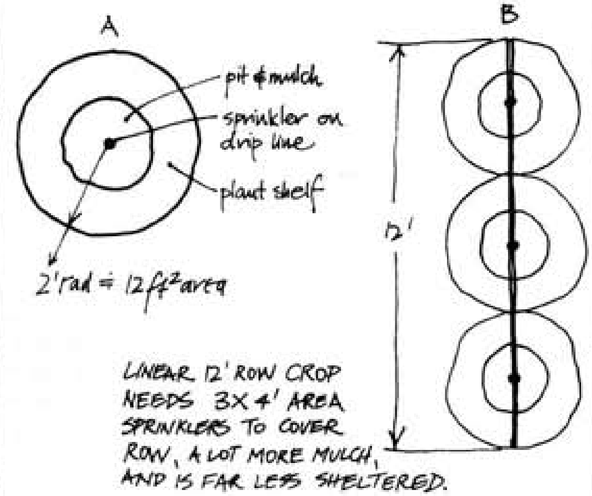


FIGURE 4.31
ROW CROP OR CIRCLE CROP
Here, a 4 m row of crop needs three 1.2 m sprinklers, while a circle of radius 0.6 m (4 m circumference) needs only one 1.2 m sprinkler, a saving of 60% in water use. Such systems apply only on the small scale, where plants can shade the inner circle.

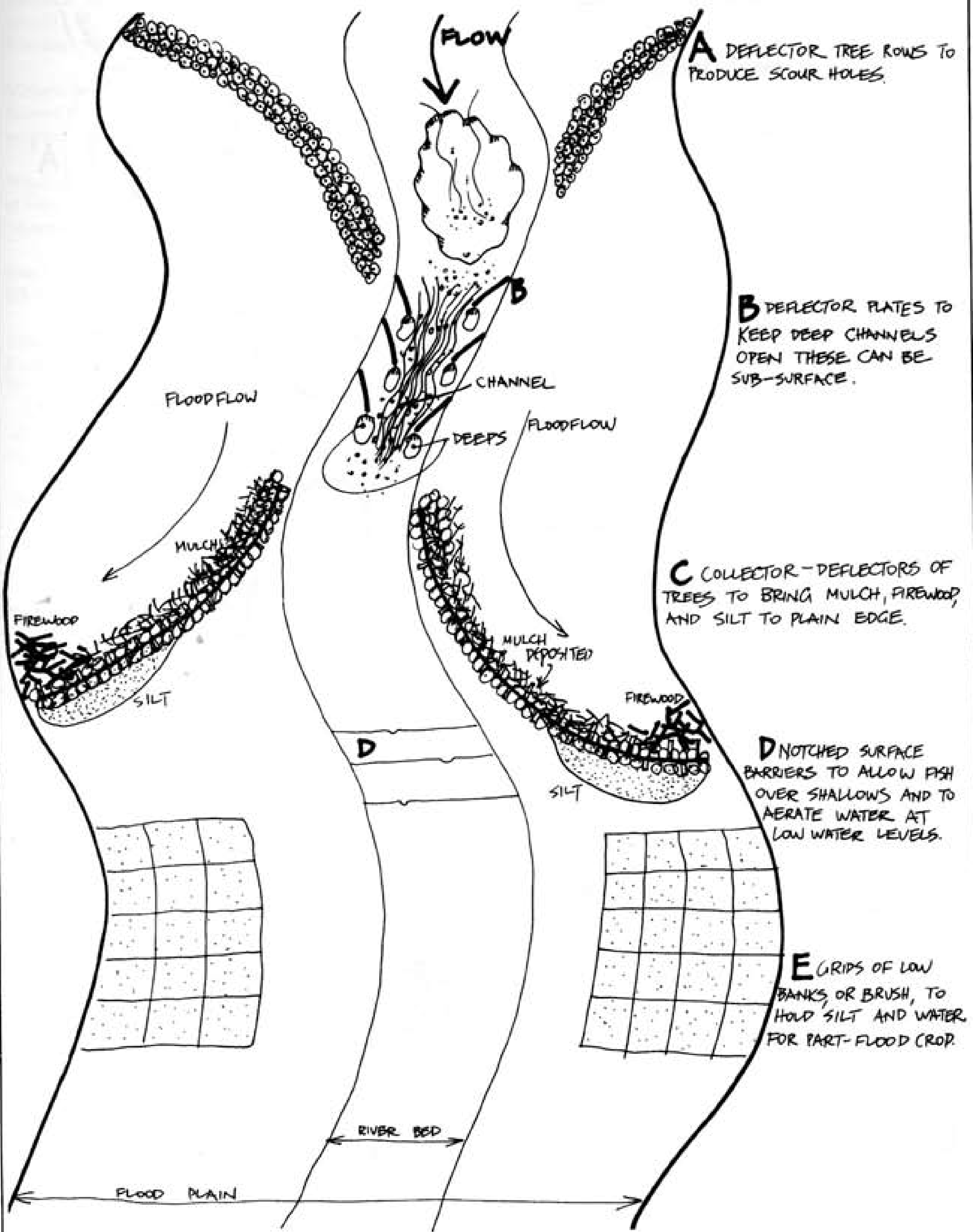


FIGURE 4.32
FLOW INTERCEPTORS ON FLOOD PLAIN.
Floodwaters carry silt, mulch, and firewood and can be used to scour out river sand. Here, several structures on a flood plain gather materials or direct water energy to benefit production.

Birch, and Cobb, *The Liberation of Life*, Cambridge University Press, 1981.

Bohm, *Wholeness and Implicate Order*, Routledge and Kegan Paul, 1980.

Capra, Fritz, *The Tao of Physics*, Fontana Press, 1976.

Cook, Sir Theodore Andrea, *The Curves of Life*, Constable, London, 1914 (reprint)

Escher, M. C. and J. L. Locher, *The World of M.C. Escher*, Harry N. Abrams Inc. New York, 1971.

Goold, J. *et alia*, *Harmonic Vibrations and Vibration Figures*, Newton & Co. London, 1909.
(see also: *Model Engineer* 3 May '51, 8 Sep '60; *Hobbies* Nov 1966; and *New Scientist* 22/29 Dec '83).

Illert, Christopher, *Sea Shell Mathematics*, self-published, 1984: 76 Seaview Rd., West Beach, South Australia 5024.

Lovelock, J. E., *Gaia: A New Look at Life on Earth*, Oxford University Press, 1979.

Leapfrogs, *Curves*, Tarquin Pubs. Stradbroke, Diss, Norfolk, U.K., 1985.

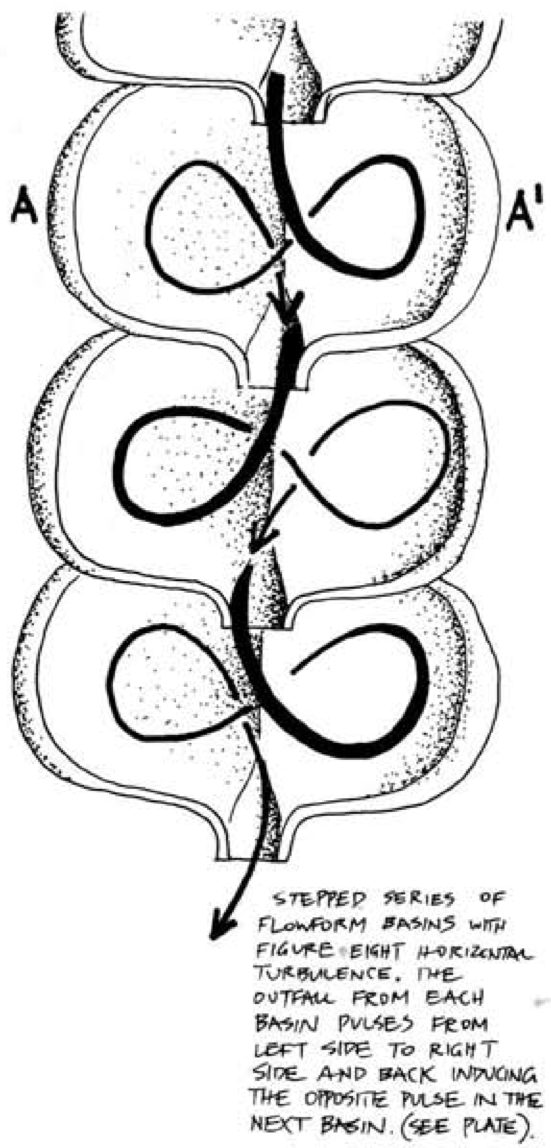
Mandelbrot, Benoit, *The Fractal Geometry of Nature*, W.H. Freeman Co. New York, 1982.
(The basic book on fractals, computer graphics)

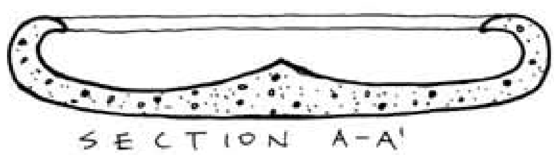
Murchie, Greg, *The Seven Mysteries of Life*, 1984, self-published: Marlborough, NH, USA.

Pearce, Peter, *Structure in Nature as a Strategy for Design*, M.I.T. Press, 1979.

Schwenke, Theodore, *Sensitive Chaos; the Creation of Flowing Forms in Air or Water*, Schocken Books, N.Y., 1976.

Thompson, D'arcy W., *On Growth and Form*, Cambridge University Press, 1952.
(Multiple examples of forms in nature, spirals)





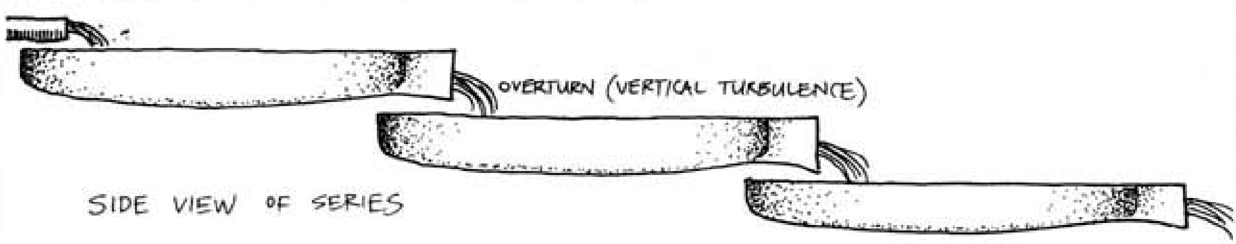


FIGURE 4.33
FLOWFORMS.
Of ancient usage, and natural occurence, can be neatly fabricated in concrete or glass reinforced plastic to aerate water in the case of a constant (or little varying) flow.

Tweedie, A. D., *Water and the World*, Thos. Nelson (Aust) Ltd., 1975.
(On the order of stream flow and stream patterns)

Virbela Institute, Emerson College, Forest Row, East Sussex RH18 5JX (Flowform designs and research, posters.)

Vogel, Steven, *Life in Moving Fluids; the Physical Biology of Flow*, Willard Grant Press, Boston, 1981.
(A sensitive and scholarly study of life forms in flow)

Weyl, Hermann, *Symmetry*, Princeton University Press, NJ, USA, 1983.

New Scientist, New Science Publications, Commonwealth House, 1–19 New Oxford St. London WC1A 1NG:

5 Oct '78 :	On pulsers and biological clocks
15 Nov '84 :	On the gravity anomalies in the geoid
31 May '84 :	The Robinson Congruence
7 Jun '84 :	Recombination of DNA in a plus–torus
20 Mar '79 :	The swirling of water
14 Jun '79 :	The spiral classification of galaxies
5 May '83 :	Symmetry, geometry, fractals
26 Apr '84 :	Fractals
5 May '83 :	Inversion and reflection of forms
17 Nov '83 :	On impact craters
21 Apr '77 :	"The great tennis ball of earth"
11 Oct '84 :	The pineal gland as a timepiece
4 Apr '85 :	Fractals, pulsars, black holes

4.28

DESIGNER'S CHECKLIST

Read in pattern analysis, and study the relationships of ORDERS and FORMS in nature. Patterned systems must be of appropriate size, or of the right order (i.e. note that *small* systems operate for things like frost protection and water conservation in crop).

When designing gardens, ponds, or access ways, try to minimise waste space by using spiral, keyhole, and least–path systems, clumped plantings, and sophisticated interplants.

Study and use edge effects, especially in relation to intercrop and in the construction of plant guilds, pond production, and fail–safe species richness in variable climatic regimes.

Use appropriate patterns to direct energies on site, and to lay out the whole site for zone, sector, slope, and orientation benefits. This approach alone creates the most energy savings.