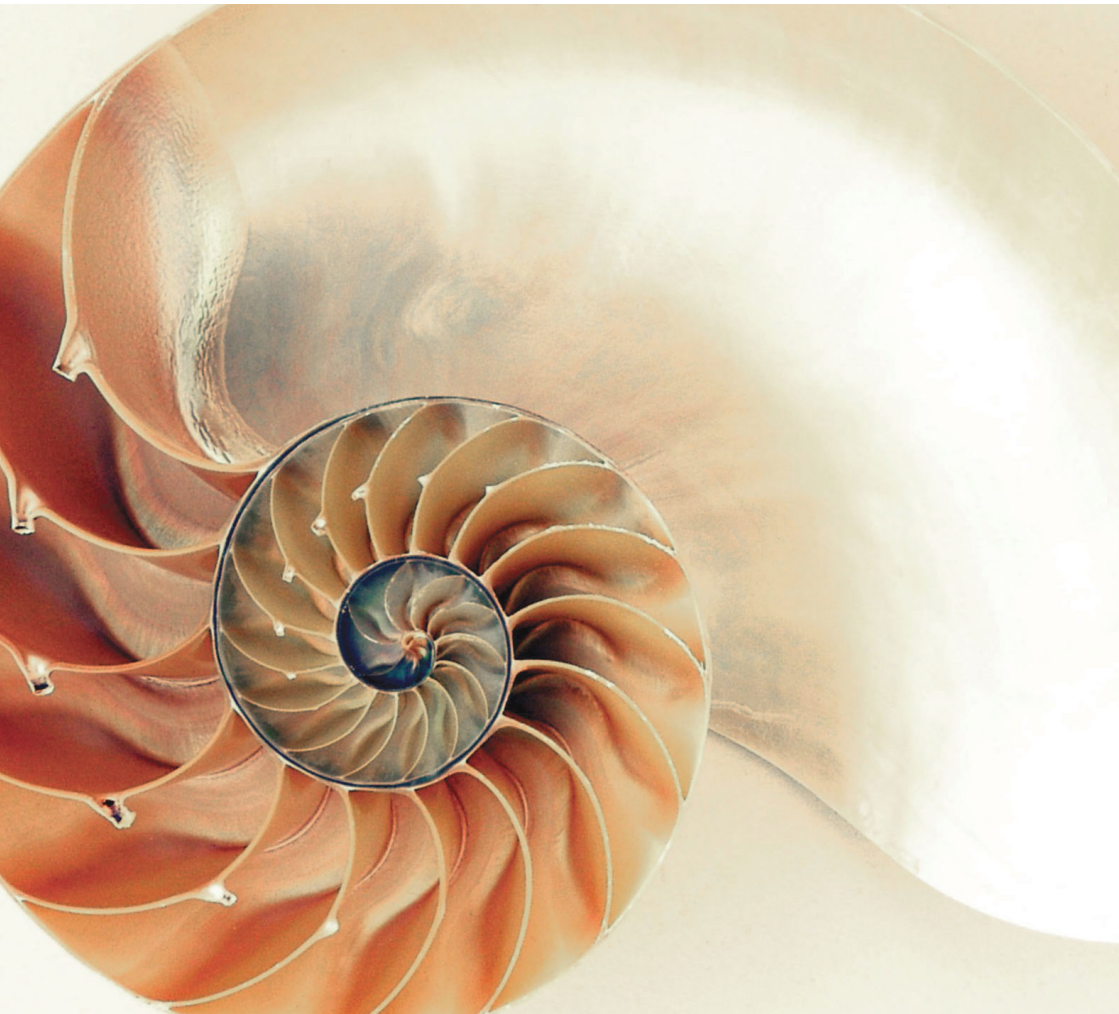


GreenSpirit pamphlets

# How Things Come To Be

Michael Colebrook



# How Things Come To Be

## GreenSpirit

GreenSpirit, the Association for Creation Spirituality in Britain, is part of a widespread movement exploring different ways of seeing, and living in, our world. More and more people are realising that we cannot continue using the earth and her creatures as if we owned them, increasing the gap between the haves and the have-nots in society, and despoiling the earth.

New insights from ecology, psychology and the physical sciences, linking the latest Western knowledge and understanding to traditional wisdom, can lead us to a different way of perceiving our presence on earth. We need a profound shift in thinking and feeling to convert the present over-consumption to a simpler, more compassionate way of living here.

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6. *Imagining Otherwise.* Lindsay Clarke, 2004.

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Published by GreenSpirit  
The Association for Creation Spirituality  
137 Ham Road  
Forest Gate, London E7 9LE  
Registered Charity No. 1045532  
[www.greenspirit.org.uk](http://www.greenspirit.org.uk)

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**Note**

The cover of this pdf has been newly designed to fit the style of other early GreenSpirit pamphlets now available for free from GreenSpirit in pdf format.

## ACKNOWLEDGEMENTS

My thanks are due to Faber and Faber for permission to include the scene from Tom Stoppard's play *Arcadia*. Also to Jean Hardy's Schumacher Tuesday Group on whom I tried out most of the ideas in my essay. Several people read and provided me with valuable comments on various drafts of the text including Christine Avery, Chris Clarke and Ian Mowll.

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## Introduction

*[Mother Carey] sat quite still with her chin upon her hand, looking down into the sea with two great grand blue eyes, as blue as the sea itself. Her hair was as white as the snow – for she was very very old – in fact, as old as anything which you are likely to come across, except the difference between right and wrong. And, when she saw Tom, she looked at him very kindly...*

*"I heard, ma'am, that you were always making new beasts out of old."  
"So people fancy. But I am not going to trouble myself to make things, my little dear. I sit here and make them make themselves."*

*Charles Kingsley. The Water Babies. 1863.*

It is often said that the ultimate question addressed by philosophy is, ‘Why is there something rather than nothing?’ This essay takes several steps back from this question and attempts to make a contribution towards the answer to the question, ‘granted that there is something, or rather an enormous number of different somethings, how have they come to be?’ Finding out about the ‘how’ may contribute towards finding the answer to the ‘why’. There is a tendency for studies of this kind to focus either on the very small, the quantum world, or the very big, the realm of cosmology. The intention here is to focus on the things that are present to our everyday experience, the kinds of things that we would regard as constituting the natural world.

The processes of making human-made objects involve an element of intention and nearly always an element of design. Vast areas of human endeavour are involved in the processes of making things and also in the creative activities of making better things and making new things. The processes

of making, of intentionality, the implementation of design, and the emergence of order are so much part of our everyday experience that we take them for granted.

There is an obvious and understandable tendency to carry over ideas about the processes of making derived from human activities and to apply them to the natural world. Based on the kind of making that we have done we look for parallels in the natural world and assume that the same aspects of intentionality and design and the appearance of order are involved

When we look at the things that make up the natural world we see a totally bewildering variety of objects, many of which exhibit a level of complexity that far outstrips anything made by human hands. We see seemingly inexorable forces at work that dwarf anything we can do. At the same time, the natural world creates the impression of being intelligible. There is clear evidence of pattern and order, to which we naturally ascribe the process of design, and we find it difficult not to invoke the quality of intentionality.

At the level of understanding implied by ideas about design, intentionality and the emergence of order, the traditional view within Western culture of how things come to be involves an external creator who can express intention and do the designing. The study of the natural world aimed specifically at discerning the role of the creator has a long history. Such studies tend to be centred within the discipline that is now known as natural theology. One of the foundational works is *The Wisdom of God Manifested in the Works of Creation* by John Ray (1691) in which he states, “you may hear illiterate Persons of the lowest Rank of the Commonality affirming, that they need no proof of the being of God, for that every Pile of Grass, or Ear of Corn, sufficiently proves that. For, say they, All the men in the World cannot make such a thing as one of these; and if they cannot do it, who can, or did make it but God? To tell them that it made itself, or sprung up by chance, would be as ridiculous as to tell the greatest Philosopher so.”

Probably the best known statement of natural theology is by William Paley. “In crossing a heath, suppose I pitched my foot against a *stone*, and were

asked how the stone came to be there; I might possibly answer, that, for anything I knew to the contrary, it had lain there for ever ... But suppose I had found a *watch* upon the ground, and it should be inquired how the watch happened to be in that place; I should hardly think of the answer which I had before given ... Yet why should not this answer serve for the watch as well as for the stone? ... The inference, we think, is inevitable, that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." Paley's book *Natural Theology* stayed on the reading lists of several departments of theology until well into the 20<sup>th</sup> century.

More recently, Keith Ward has claimed that a theistic explanation provides the most economical and fruitful basis for how things come to be. Economical because the being of everything can be attributed to just one cause and fruitful because it provides the basis for confidence in the intelligibility of the world. He goes on to state that, "the theistic hypothesis is a better one than the materialist hypothesis, because it makes the existence of a universe like this very much more probable than materialism does."

Each of these three statements use human ability and intelligence as the yardstick with which to assess of the probability of a divine cause of the existence of things. Working within the constraints of human abilities and human experiences of making things, the argument for the role of design and intentionality in the creation of the natural world seems reasonable. It is, however, based on the supposition that the stuff of the universe, matter and energy, are passive phenomena that need to be worked on and transformed before any creative activity can emerge.

Pierre Teilhard de Chardin had a higher opinion of matter, "Blessed be you, mighty matter, irresistible march of evolution, reality ever new-born; you who, by constantly shattering our mental categories, force us to go ever further and further in our pursuit of the truth..."

Blessed be you, universal matter, immeasurable time, boundless ether, triple abyss of stars and atoms and generations: you who by overflowing and dissolving our narrow standards of measurement reveal to us the dimensions of God...

I acclaim you as the divine *milieu*, charged with creative power..."

Teilhard de Chardin was a keen advocate of evolutionary theory, but in this passage he seems to be suggesting that there is creative potential within matter itself. He claims that the universe as we now know it, a universe of immeasurable time, seemingly boundless space and endless variety cannot be confined within human understanding and our 'narrow standards of measurement'.

In this essay I want to look at a number of ideas which may contribute to our understanding of how things come to be from within the inherent properties of the material world. I have chosen as my starting point some recent developments within the discipline of General Systems Theory. This is a discipline which looks at things by observing and analysing their behaviour, as opposed to taking them apart to see what they are made of. It is basically a holistic approach to the study of the way things are. I will focus on two artificial systems which look like computer games but are actually much more interesting (pp. 18-33).

To provide a gentle introduction to what may be unfamiliar ideas and to set the scene for the exploration of the possibility of a materialistic, but not necessarily non-theistic, explanation of the processes by which the natural world has come to be, with systems theory as its starting point, the following is part of a dialogue from a play called *Arcadia* by Tom Stoppard.

## A Scene from *Arcadia*

*The play is set in a room on the garden front of a very large country House in Derbyshire. The action of the play shuttles back and forth between the early nineteenth century and the present day, in which the following scene is set. It is a conversation between Valentine Coverly, a member of the family, and Hannah Jarvis, who is doing historical research on the garden. In looking for old records, a maths primer and a work-book were found which belonged to Thomasina Coverly, daughter of the house, who has appeared in the scenes set in the nineteenth century. The dialogue is from Act 1 Scene 4.*

HANNAH *is reading aloud.* VALENTINE *is leafing through Thomasina's work book as he listens to HANNAH reading from the primer.*

HANNAH: 'I, Thomasina Coverly, have found a truly wonderful method whereby all the forms of nature must give up their numerical secrets and draw themselves through number alone. This margin being too mean for my purpose, the reader must look elsewhere for the New Geometry of Irregular Forms discovered by Thomasina Coverly.'

*(Pause. She hands VALENTINE the book. VALENTINE looks at what she has been reading. From the next room, a piano is heard, beginning to play quietly, unintrusively, improvisationally.)*

Does it mean anything?

VALENTINE: I don't know. I don't know what it means, except mathematically.

HANNAH: I meant mathematically.

VALENTINE: *(Now with the lesson book again)* It's an iterated algorithm.

HANNAH: What's that? Is it difficult?

VALENTINE: The maths isn't difficult. It's what you did at school. You have some  $x$ -and- $y$  equation. Any value for  $x$  gives you a value for  $y$ . So you put a dot where it's right for both  $x$  and  $y$ . Then you take the next value for  $x$  which gives you another value for  $y$ , and when you've done that a few times you join up the dots and that's your graph of whatever the equation is.

HANNAH: And is that what she's doing?

VALENTINE: No. Not exactly. Not at all. What she's doing is, every time she works out a value for  $y$ , she's using *that* as her next value for  $x$ . And so on. Like a feedback. She's feeding the solution back into the equation, and then solving it again. Iteration, you see.

HANNAH: And that's surprising, is it?

VALENTINE: Well, it is a bit. It's the technique I'm using on my grouse numbers, and it hasn't been around for much longer than, well, call it twenty years. *(Pause.)* When your Thomasina was doing maths it had been the same maths for a couple of thousand years. Classical. And for a century after Thomasina. Then maths left the real world behind, just like modern art, really. Nature was classical, maths was suddenly Picassos. But now nature is having the last laugh. The freaky stuff is turning out to be the mathematics of the natural world.

HANNAH: What did you mean you were doing the same thing she was doing?

*(Pause.)* What *are* you doing?

VALENTINE: Actually I'm doing it from the other end. She started with an equation and turned it into a graph. I've got a graph – real data – and I'm trying to find the equation which would give you the graph if you used it the way she's used hers. Iterated it.

HANNAH: What for?

VALENTINE: It's how you look at population changes in biology. Goldfish in a pond, say. This year there are  $x$  goldfish. Next year there'll be  $y$  goldfish. Some

get born, some get eaten by herons, whatever. Nature manipulates the  $x$  and turns it into  $y$ . Then  $y$  goldfish is your starting population for the following year. Just like Thomasina. Your value for  $y$  becomes your next value for  $x$ . The question is: what is being done to  $x$ ? What is the manipulation! Whatever it is, it can be written down as mathematics. It's called an algorithm.

HANNAH: It can't be the same every year.

VALENTINE: The details change, you can't keep tabs on everything, it's not nature in a box. But it isn't necessary to know the details. When they are all put together, it turns out the population is obeying a mathematical rule.

HANNAH: The goldfish are?

VALENTINE. Yes. No. The numbers. It's not about the behaviour of fish. It's about the behaviour of numbers. This thing works for any phenomenon which eats its own numbers – measles epidemics, rainfall averages, cotton prices, it's a natural phenomenon in itself. Spooky.

HANNAH: Does it work for grouse?

VALENTINE: I don't know yet. I mean, it does undoubtedly, but it's hard to show. There's more noise with grouse.

HANNAH: Noise?

VALENTINE: Distortions. Interference. Real data is messy. There's a thousand acres of moorland that had grouse on it, always did till about 1930. But nobody counted the grouse. They shot them. So you count the grouse they shot. But burning the heather interferes, it improves the food supply. A good year for foxes interferes the other way, they eat the chicks. And then there's the weather. It's all very, very noisy out there. Very hard to spot the tune. Like a piano in the next room, it's playing your song, but unfortunately it's out of whack, some of the strings are missing, and the pianist is tone deaf and drunk – I mean, the *noise*! Impossible!

HANNAH: What do you do?

VALENTINE: You start guessing what the tune might be. You try to pick it

out of the noise. You try this, you try that, you start to get something – it’s *half-baked* but you start putting in notes which are missing or not quite the right notes ... and bit by bit ... (*He starts to dumdi-da to the tune of Happy Birthday*.) Dumdi-dum-dum, dear Val-en-tine, dumdi- dum-dum to you – the lost algorithm!

HANNAH: (*Soberly*) Yes, I see. And then what!

VALENTINE: I publish.

HANNAH: Of course. Sorry. Jolly good.

VALENTINE: That’s the theory. Grouse are bastards compared to goldfish.

HANNAH: Why did you choose them?

VALENTINE: The game books. My true inheritance. Two hundred years of real data on a plate.

HANNAH: Somebody wrote down everything that’s shot?

VALENTINE: Well, that’s what a game book is. I’m only using from 1870, when butts and beaters came in.

HANNAH: You mean the game books go back to Thomasina’s time?

VALENTINE: Oh *yes*. Further. (*And then getting ahead of her thought.*) No – really. I promise you. I *promise* you. Not a schoolgirl living in a country house in Derbyshire in eighteen-something!

HANNAH: Well, what was she doing?

VALENTINE: She was just playing with the numbers.

(HANNAH *picks up the algebra book and reads from it.*)

HANNAH: ‘... a method whereby all the forms of nature must give up their numerical secrets and draw themselves through number alone.’ This feedback, is it a way of making pictures of forms in nature! Just tell me if it is or isn’t?

VALENTINE: (*Irritated*) To *me* it is. Pictures of turbulence – growth – change – creation – it's not a way of drawing an elephant, for God's sake! The unpredictable and the predetermined unfold together to make everything the way it is. It's how nature creates itself, on every scale, the snowflake and the snowstorm. It makes me so happy. To be at the beginning again, knowing almost nothing. People were talking about the end of physics. Relativity and quantum theory looked as if they were going to clean out the whole problem between them. A theory of everything. But they only explained the very big and the very small. The universe, the elementary particles. The ordinary-sized stuff which is our lives, the things people write poetry about – clouds – daffodils – waterfalls – and what happens in a cup of coffee when the cream goes in – these things are full of mystery, as mysterious to us as the heavens were to the Greeks. We're better at predicting events at the edge of the galaxy or inside the nucleus of an atom than whether it'll rain on auntie's garden party three Sundays from now. Because the problem turns out to be different. We can't even predict the next drip from a dripping tap when it gets irregular. Each drip sets up the conditions for the next, the smallest variation blows prediction apart, and the weather is unpredictable the same way, will always be unpredictable. The future is disorder. A door like this has cracked open five or six times since we got up on our hind legs. It's the best possible time to be alive, when almost everything you thought you knew is wrong.

## Conway's Game of Life

To say of a Pile of Grass, or Ear of Corn, that it made itself, or sprung up by chance, may have sounded ridiculous to John Ray. But subsequent developments in evolutionary theory and systems theory have clearly brought such ideas into the realm of the possible.

In the dialogue, Valentine makes the very substantial claim that, “The unpredictable and the predetermined unfold together to make everything the way it is. It’s how nature creates itself.” The process involves, in Valentine’s words, “the ordinary-sized stuff which is our lives, the things people write poetry about – clouds – daffodils – waterfalls”.

The intention of this essay is to see if it is possible to put some flesh on the bare bones of Valentine’s idea that nature creates itself. That somehow things like clouds and daffodils and waterfalls have created themselves. But also to see whether this can be reconciled with the involvement of any mode of design or of a designer. We are not directly concerned with the creation of something out of nothing, but with the creative transformations of ‘the stuff of the universe’ manifest as complex entities like clouds and daffodils and waterfalls, the real things of the real world.

The philosopher Alfred North Whitehead says that, “Creativity is the universal of universals characterising ultimate matter of fact... It lies in the nature of things that the many enter into complex reality.”

He claims that it is in the nature of things to come into relationship with each other forming ‘complex reality’. That the wholes so formed represent more than simply the sums of the parts involved and are, therefore, the result of creativity.

Many of the more significant events in the evolutionary story of the universe confirm Whitehead’s sweeping generalisation. Sub-atomic particles come together to form atoms. Atoms come together to form molecules, molecules come together to form compounds. All around us, and including us, it is clear that things come together to form the complex reality of the world in which we exist. Bits come together to form wholes over an enormous range of sizes and degrees of complexity, from galactic clusters to the minutest speck of dust. We are aware of how the bits of a car or of a television set can be brought together to form the whole manufactured article. Less obvious is how things in the natural world come together to form a reality the complexity of which is far beyond human capability.

It has been the task of the sciences to attempt to discover and describe how the world in which we exist has come to be. As Valentine says, we know quite a lot about the very big and the very small but, “the ordinary-sized stuff which is our lives, the things people write poetry about – clouds – daffodils – waterfalls – and what happens in a cup of coffee when the cream goes in – these things are full of mystery.” In this area, we see the results of things coming together but we seldom appreciate, or are even aware of, the processes involved.

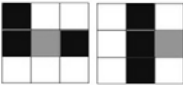
It is possible to illustrate how the many may enter into complex reality by using a form of iterated algorithm known as Conway’s Game of Life (see Box 1).

The initial arrangement of black cells in Box 2 (*a*) is important because it is the simplest arrangement which both moves and cycles. Every four moves the whole pattern is displaced diagonally by one cell and it also repeats itself. The pattern is known as a simple glider. In successive moves the pattern glides diagonally across the grid of squares.

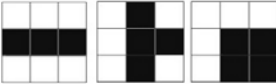
### BOX 1: Conway's Game of life

This is one of a family of systems known as cellular automata. These can be thought of as games played on large grids of squares, each square being a cell. The rules of each game, the algorithms, determine how the cells may change colour. In Conway's Game of Life, all the cells start out in a default colour (say white) and the rules determine a single colour change (say black). Games start by entering an initial arrangement of black cells. The algorithm consists of three rules:—

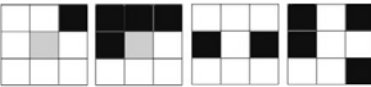
A white cell with three black neighbours turns black (birth)



A black cell with two or three black neighbours stays black (survival)



In all other cases the cell turns or stays white



In the following pages graphics are used to illustrate several forms of the Game of Life. These do not have the same impact as seeing the games played, move by move, on a computer screen.

Readers are strongly recommended to play the games for themselves.

Possibly the best implementation of the game is Life32 that can be downloaded as a zip file from: <http://psoup.math.wisc.edu/Life32.html>

A wide range of starting patterns exhibiting a wide range of behaviours that can be run with Life32 can be downloaded from:

<http://www.entropymine.com/jason/life/>

Scroll down and download **jslife** (315KB). This contains a number of folders each containing a number of patterns. In particular the pattern for Box 2b is in the folder **synthesis** and the file is **Make-p33.lif**

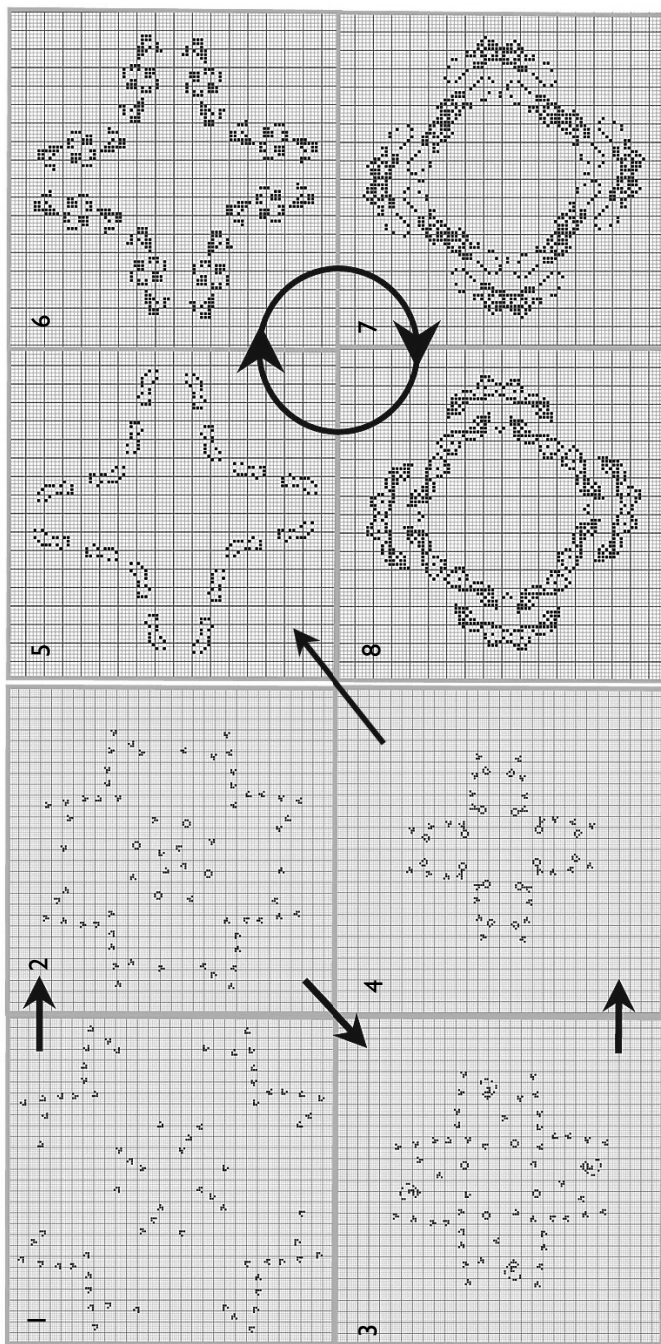
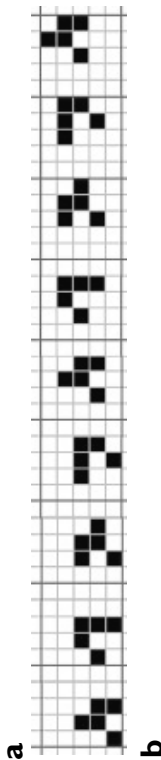
Diagram *b,1* in Box 2 shows a particular arrangement of 68 simple gliders. In successive moves (diagrams 2, 3 & 4) the gliders come together and their interactions produce the complex cyclic pattern shown in diagrams 5 to 8 — ‘the many enter into complex reality’.

The initial arrangement is critical. If any of the 68 gliders is altered in any way, the whole pattern dissolves into chaos. This poses William Paley's dilemma in a particularly acute form. Because the initial arrangement is so critical it is difficult to avoid the conclusion that it was designed, as indeed it was. But, unlike Paley's watch, the outcome, the cyclic pattern, could not be the result of a specific intention. Only in the very simplest of cases can the outcome of any game be predicted and even then only for a few moves ahead.

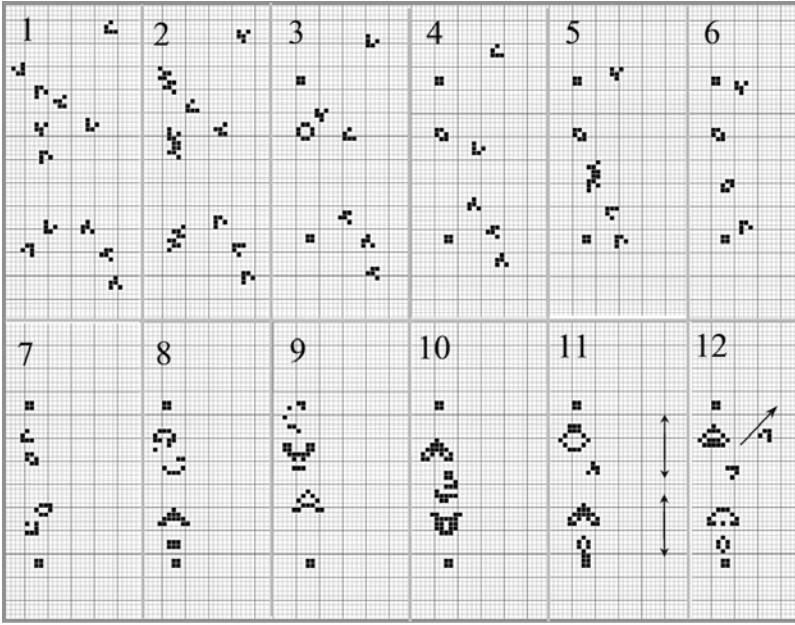
The initial arrangement was developed by trial and error, enhanced by experience, through exploring the many ways in which simple gliders interact with each other. The intention could only be to produce some form of complex cyclic pattern.

## BOX 2

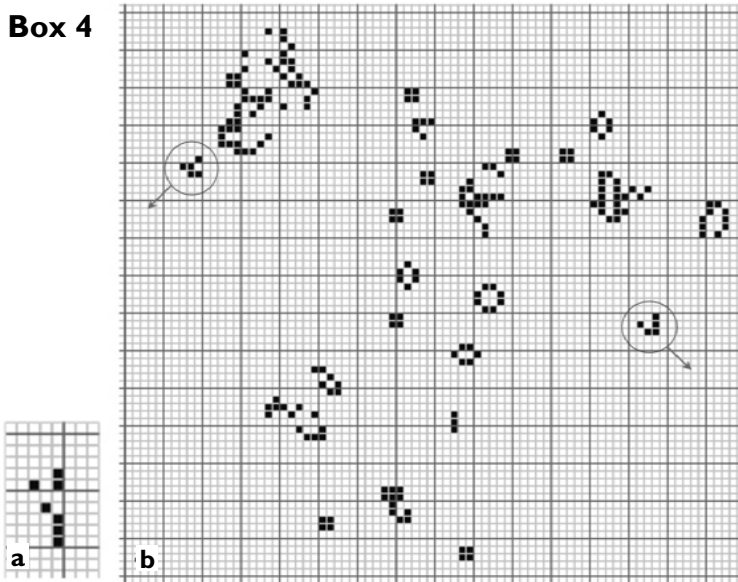
In this form of Conway's Game of Life the initial state consists of a symmetric pattern of 68 simple gliders (top left). Over a series of about 150 moves these all come together and the result of their interactions is a cyclic sequence of 33 moves, four of which are illustrated below.



### BOX 3



### Box 4



In the repertoire of established initial arrangements for Conway's Game of life many of them are different arrangements of simple gliders that have various outcomes. One of them is shown in Box 3. It consists of just twelve simple gliders. Over successive moves these interact to produce an oscillating cyclic pattern which, at each oscillation, produces a simple glider. Gliders can reproduce themselves. In this instance the outcome was already known and the design element was restricted to producing it using an arrangement of simple gliders.

In both cases (Boxes 2 & 3) the outcomes clearly represent more than simply the sum of the parts involved. In both cases the outcomes are the product of interactions between the parts amounting in many instances to total transformations and resulting in the emergence of new and unpredictable behaviours.

The outcomes of most of the possible initial arrangements of black squares are chaotic, and many of them 'die' or 'freeze' after a few moves or a few tens of moves. Equally, many of them involve transient but clearly ordered patterns and many also produce simple gliders. Box 4 is an example in which the successive moves, starting with the very simple initial arrangement (a), create a chaotic pattern which runs for about 5000 moves before becoming a collection of static elements. In the process it produces thirteen simple gliders, two of which are shown in (b).

Conway's Game of Life raises questions about the relationship between order and chaos and about the nature of creativity which will be explored later on. But first we will look at another form of cellular automaton the properties of which also contribute to ideas about creativity.

## On Cellular Automata

In Greek mythology, the machinery of the universe was the gods themselves ... In more recent conceptions, the universe is created complete with its operating mechanism: once set in motion, it runs by itself. God sits outside of it and can take delight in watching it.

Cellular automata are stylized, synthetic universes ... They have their own kind of matter which whirls around in a space and a time of their own. One can think of an astounding variety of them. One can actually construct them, and watch them evolve. As inexperienced creators, we are not likely to get a very interesting universe on our first try; as individuals we may have different ideas of what makes a universe interesting, or of what we might want to do with it. In any case, once we've been shown a cellular-automaton universe we'll want to make one ourselves; once we've made one, we will want to try another one. After having made a few, we'll be able to custom-tailor one for a particular purpose with a certain confidence.

A cellular automata machine is a universe synthesizer. Like an organ, it has keys and stops by which the resources of the instrument can be called into action, combined, and reconfigured. Its colour screen is a window through which one can watch the universe that is being "played."

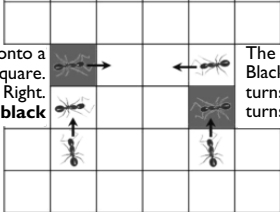
Toffoli, T. & N. Margolus. *Cellular Automata Machines: A New Environment for Modelling* (MIT Press, 1987), p.1.

Quoted in Evelyn Fox Keller. *Making Sense of Life* (Harvard University Press, 2002)

## Langton's Ant

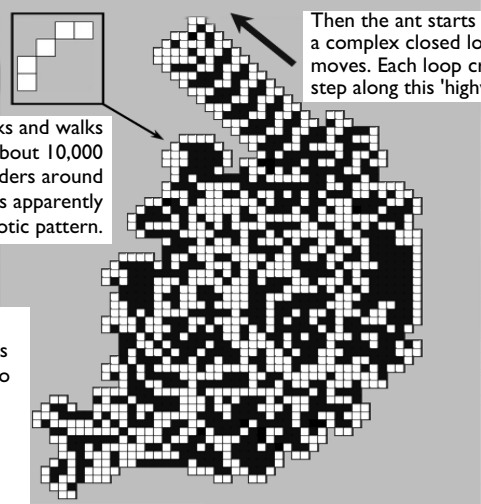
There is another form of cellular automaton which has been studied from the point of view of exploring the relationship between chaos and order. It is known as Langton's Ant.

**BOX 5**      Langton's Ant: the basic two-colour rule



The Ant walks onto a White square. The Ant turns Right. The square turns **black**

The Ant walks onto a Black square. The Ant turns Left. The square turns **white**



The ant walks and walks and for about 10,000 moves it meanders around and creates this apparently chaotic pattern.

Then the ant starts walking in a complex closed loop of 104 moves. Each loop creates a step along this 'highway'.

As with Conway's Game of life, readers are recommended to play with Langton's Ant for themselves. A good programme can be downloaded from:

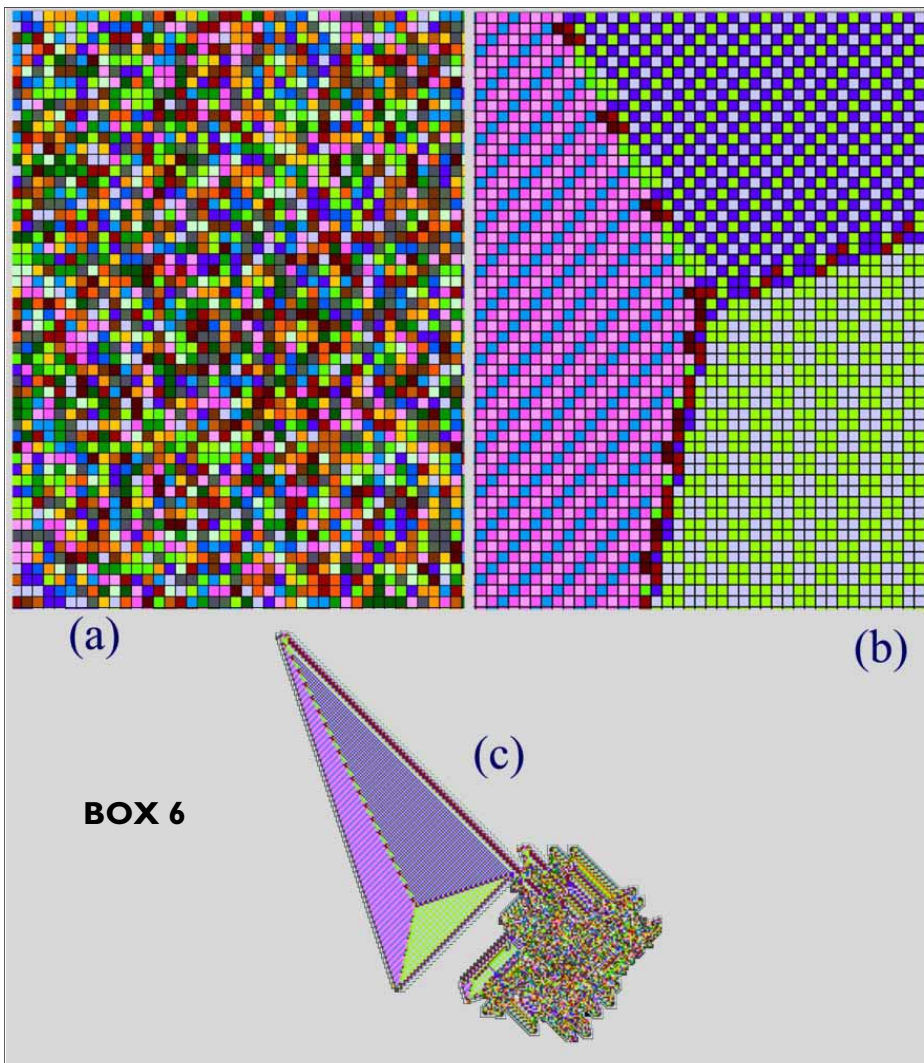
[http://fvdp.homestead.com/files/ant\\_index.html](http://fvdp.homestead.com/files/ant_index.html)  
The programme is called Ant-ology and is available as a 200Kb zip file.

Imagine an ant standing on one of a large grid of squares. For each move of the game the ant walks onto an adjacent square where it either turns left or turns right and continues to walk onto another square. The direction in which the ant turns, is determined by the colour of the square it walks onto. The square then changes colour depending on the colour of the square the ant has walked from.

In the original form of the system developed by Christopher Langton (see Box 5) there are just two colours, black and white. In developed forms of the game the algorithm consists of a sequence of right and left turns each associated with a particular colour.

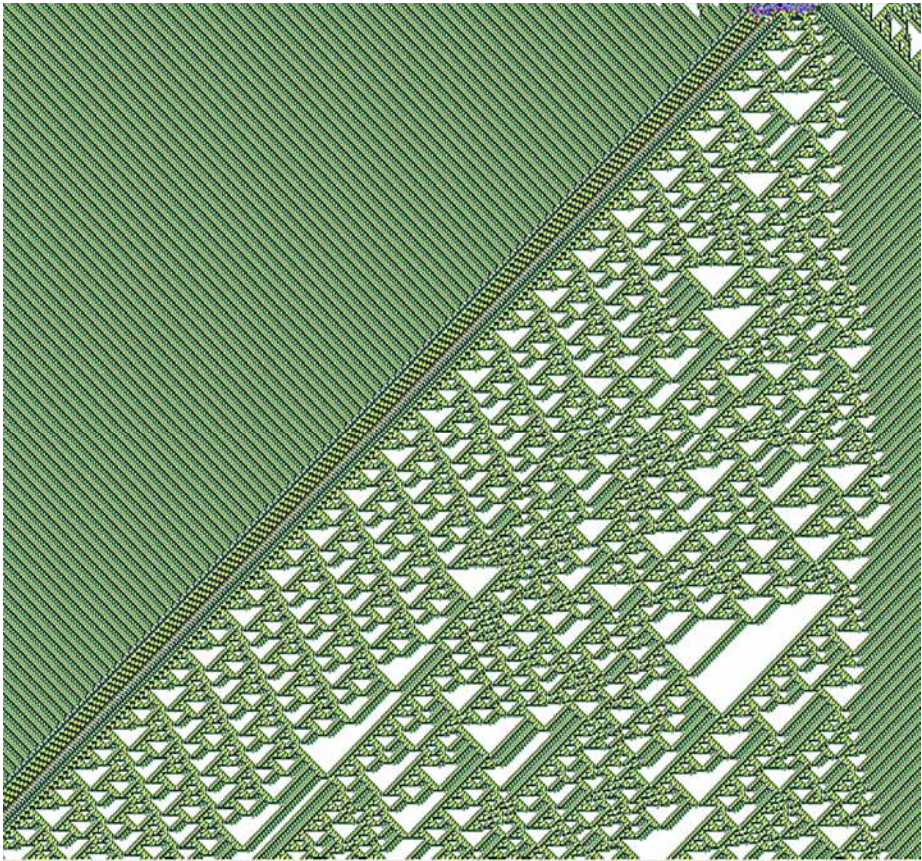
Box 6 contains sections of patterns resulting from a walk by Langton's Ant involving 21 different colours. They may be considered to be computer-age equivalents of Paley's watch and stone. Pattern (a) is the equivalent of Paley's stone, it is a disordered collection of coloured squares that could have come together by chance. Pattern (b) is the equivalent of Paley's watch; it is a collection of squares clearly arranged in an orderly pattern and we might well say, with Paley, that it "must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers ... who comprehended its construction, and designed its use." In this case the 'artificer' who wrote the computer programme. In fact both diagrams are parts of a much larger pattern (also shown in Box 6) produced during the same run of a particular sequence of left and right turns associated with the various colours. Pattern (b) is not the result of any form of design, the pattern emerged spontaneously from the same dynamic system that produced pattern (a).

It is difficult to overestimate the significance of this result. It demonstrates conclusively that **order and chaos are not totally separate states, they are not irreconcilable opposites. They have to be regarded simply as different areas of a common landscape.** It so happens that in most of the patterns produced by Langton's Ant there is a clearly discernable difference between areas of order and areas of chaos. There are algorithms in which the ant switches back and forth between ordered and chaotic behaviour but the two behaviours are clearly differentiated. There are, however, a few patterns in which the distinction between order and chaos is less marked and where common elements are arranged in both orderly and apparently random ways (see Box 7).



This relationship between chaos and order is just a beginning. There are a number of other features of cellular automata in general, and Langton's Ant in particular, that relate to the problem of how things might make themselves.

Another very significant feature of Langton's Ant is that, while the same algorithm always produces the same outcome, the outcome of any particular algorithm is unpredictable. It is also the case that a substantial majority of algorithms result in chaotic outcomes. Outcomes involving ordered areas of

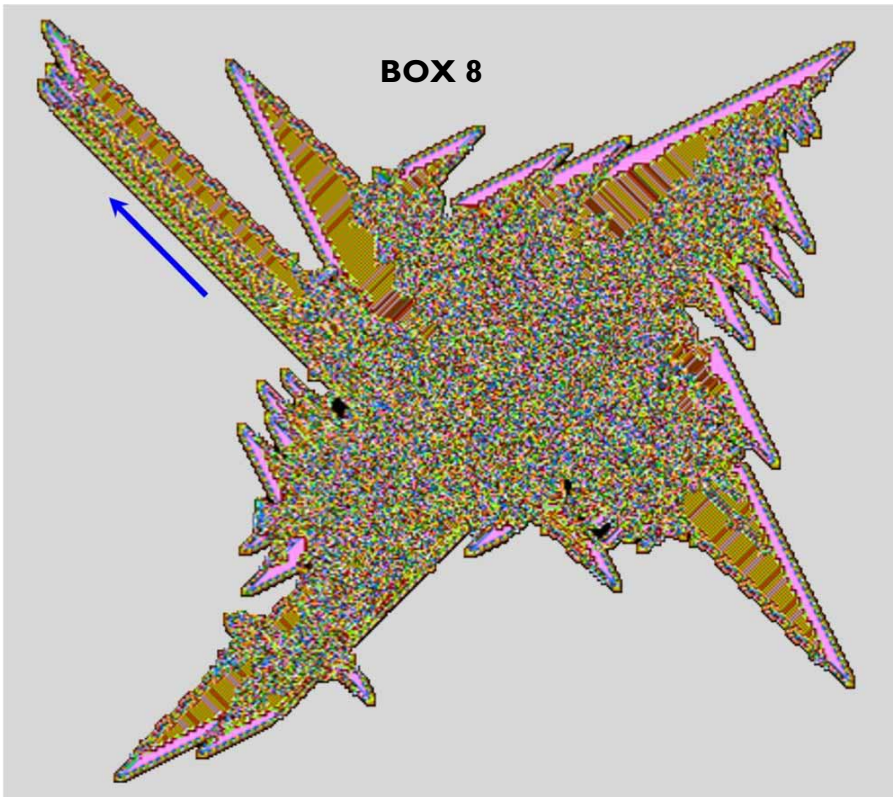
**BOX 7**

Part of a pattern produced by a walk of Langton's Ant containing obvious repeated elements. In the area on the left but below the diagonal boundary these are arranged in an orderly way and in a gradually broadening band. Below and on the right similar elements of varying size are arranged apparently at random. The whole pattern requires more than 12 million moves.

whatever kind are relatively few and far between. At the same time, there are some families of right and left sequences that are more productive of ordered patterns than others. Box 8 contains the pattern produced by an algorithm which, in addition to long sequences of chaos, produces ordered sequences of varying size. The ant does not get locked into a repeat cycle until it has made 5,380,000 moves and each repeat cycle consists of about 21,300 moves.

In general, **while rules can determine processes, the outcomes can be unpredictable.**

As with the relationship between chaos and order it is difficult to overestimate the significance of this feature. It has been a primary aim of the physical sciences to provide descriptions of the world in the form of equations for which there are analytical solutions. What this means is that for an equation in which  $y$  is a known function of  $x$  then  $y$  can be calculated directly for any value of  $x$ . There is the well known claim by the French scientist Pierre Laplace in 1810 who said, "Consider an intelligence which, at any instant, could have a knowledge of all forces controlling nature together with the momentary conditions of all the entities of which nature consists. If this intelligence were powerful enough to submit all these data to analysis it would be able to embrace in a single formula the movements of the largest bodies in the universe and those of the lightest atoms; for it, nothing would be uncertain; the future and the past would be equally present to its eyes."



He is suggesting that there is an analytical solution to “the equation of the universe”. It is now generally recognized that there are many systems in the natural world where prediction is impossible not only because of practical problems but because of the intrinsic nature of the dynamics of the systems. There are many processes that can be expressed in the form of iterated algorithms that do not have analytical solutions and for which the only way to find out how they behave is to carry out the successive calculations. Langton’s Ant is an excellent example of such a process.

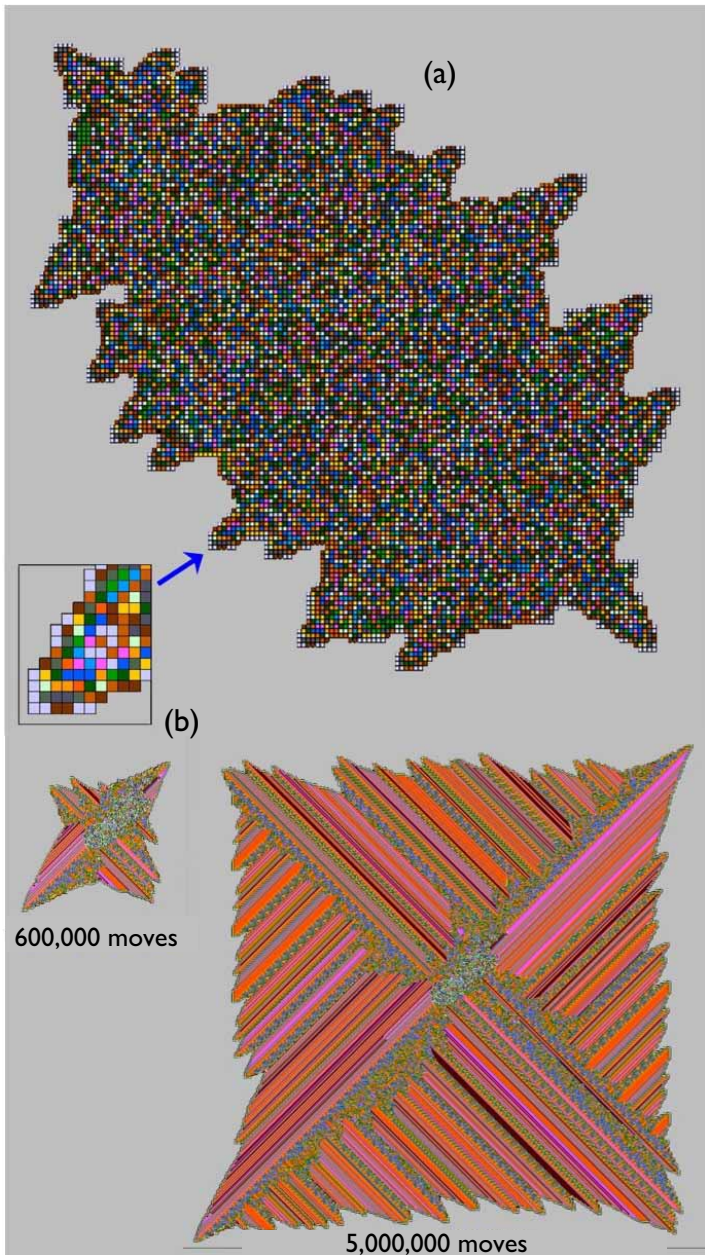
In observing the various walks of Langton’s Ant it is clear that the ordered areas are produced at the edges of the pattern and never within a chaotic area. Box 9 shows two examples of this. In (a) the pattern is almost totally disordered. Only at the tips of the ‘headlands’ is there any sign of order. In (b) after about 600,000 moves the ant is confined to walking round and round the edge.

At the edge of the pattern the ant has an increased probability of walking onto a white square and its behaviour is constrained as compared with moving around in a disordered area. It seems possible that **an element of constraint may be a significant factor in the emergence of order from chaos**. This will be examined in greater detail in a subsequent section.

There is a further significant feature of Langton’s Ant which is not so easy to illustrate with static patterns. There are quite a number of walk rules during which the ant switches back and forth between order and chaos. The pattern in Box 8 is an example, but to fully appreciate the behaviour you need to see the ant moving on a computer screen. The ant visits and revisits the ‘headland’ areas switching temporarily into cyclic sequences of moves. In ordered states the ant is locked into more or less complex cyclical sequences of moves. No further changes are possible. In disordered states the ant is largely confined to a random walk within the pattern where the creation of order cannot happen. But, there are forms of the initial rule which result in behaviour that is somewhere between chaos and order and these tend to produce the most complex ordered patterns.

Cellular automata such as Conway’s Game of Life and Langton’s Ant do exist in the real world. The patterns seen on a computer screen represent real physical events using energy provided by the computer. And, because it is possible to manipulate the rules and the other initial conditions, they provide opportunities for experiment and exploration of some of the properties of

## BOX 9



The Ant follows an almost completely chaotic path but when it encounters an edge it tends to produce small 'headlands' and the arrangement of cells at the point of each 'headland' is the same irrespective of its orientation.

For the first 600,000 moves the Ant switches between following a chaotic path and moving round and round the edge. After this the Ant is confined to moving round the edge creating an increasingly complex pattern.

dynamic systems in general. At the same time their main value is to provide analogues of events in the more natural world outside the special environments of computers.

Langton's Ant and Conway's Game of Life represent two different families of cellular automata. In the two games, the initial conditions are established in different ways. For Langton's Ant the initial state of the board is always the same with an ant sitting on a square of the default colour. The various games are set up by different developments of the basic right/left rule. For Conway's Game of Life the rule is always the same and the different games are associated with different initial arrangements of coloured squares on the board.

In spite of this difference both games exhibit the following characteristic features:

- Simple initial states and simple rules can have complex outcomes. Complexity can emerge from simplicity. The rule for Langton's Ant, for example, determines the behaviour of the ant with respect to *individual* moves. Whereas the outcomes are determined by the relationships between *all* the moves. In general the outcomes represent more than the simple sum of the elements that contribute to them.
- The outcomes may be ordered or chaotic or a combination of order and chaos. Order can emerge spontaneously from chaos. Chaos can emerge from the combination of ordered systems.
- In general the outcomes are unpredictable. The outcomes may have general features that are predictable but not the detail. For example, in Conway's Game of Life symmetrical initial arrangements preserve the symmetry even though patterns may show substantial and unpredictable changes.
- Outcomes can be very sensitive to the initial conditions.

These features clearly relate to the phenomenon of creativity. And, in so far as the features are inherent within the properties of systems, as they are in the cellular automata, they provide pointers to the ways in which things may create themselves. The relationships between complexity and simplicity and between order and chaos, the extreme sensitivity to initial conditions and the generality of unpredictability opens up a vista of almost endless potential and possibilities for the outcomes of dynamic systems. In this sense, given the rules, the features of the cellular automata suggest that the answer to the problem of

how things make themselves is that it just happens. **There is no cause, there is no design and no designer, things make themselves spontaneously, it just happens – “It lies in the nature of things that the many enter into complex reality.”**

It would seem that the problem is not ‘why are there things?’ because these appear spontaneously as part of the fundamental nature of the stuff of the universe. The problem rather has to be stated in the form of ‘why are there the particular things that we see around us in the universe?’ Things such as Valentine’s clouds, waterfalls and daffodils.

There are limitations to the value of cellular automata as analogues for systems in the natural world. They are determined by a specific algorithm, provided with a source of energy and exist in a theoretically infinite two dimensional space. There are no other external influences or factors that effect their behaviour – they represent very simple universes. One of the limitations of Langton’s Ant, for example, is that it inhabits a theoretically infinite universe and the ant can go on walking for an infinite time unless it is halted by an outside agency (the click of a mouse over the appropriate icon).

The implication is that it is not sufficient to look only at internal, inherent properties of systems, although clearly these provide the key to the making process. It is also necessary to take account of the context in which the systems exist. We need to consider the relationships between systems and their environments.

Before embarking on this it might be helpful to look at an example from the natural world of how things can come together to form a complex reality.

## Polymers

The four chemical elements that occur most abundantly in living organisms are listed in Box 10. Also listed is the number of bonds each can make with other elements. The third and fourth columns show the chemical formulae and names of simple compounds involving the four elements with the bonds indicated by lines. Hydrogen can form one bond and oxygen can form two bonds thus they form a compound with two atoms of hydrogen and one of oxygen (see Box 14 for more details). Carbon can form four bonds so the simplest compound of carbon, hydrogen and oxygen has the structure shown in the Box.

<b>BOX 10</b>			
Element	Number Of Bonds	Compound	
Hydrogen	1	H—O—H	Water
Oxygen	2	O=C=O	Carbon dioxide
Nitrogen	3	H—C≡N	Hydrogen cyanide
Carbon	4	$\begin{array}{c} \text{H} \\   \\ \text{H} > \text{C} = \text{O} \end{array}$	Formaldehyde

One of the characteristics of carbon is that it readily forms bonds with other carbon atoms forming compounds centred on chains of carbons bonded to each other. The process is known as polymerisation and the results are familiar to us



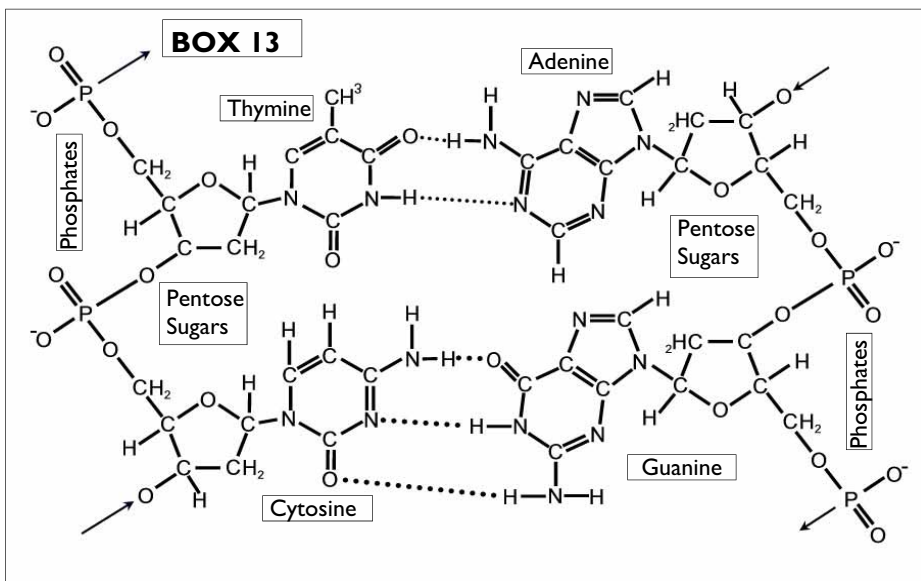
in the form of many of the plastics in everyday use. Boxes 11 & 12 show examples of the process of polymerisation involving two of the compounds from Box 10. Box 11 shows a sequence of polymers of formaldehyde. The first four polymers are centred on a straight chain of carbon atoms. In the fifth polymer, however, the chain forms a loop involving the double bonded oxygen atom. The final compound is a form of pentose sugar.

Free formaldehyde is a gas which is soluble in water where it reversibly and spontaneously polymerises.

Box 12 shows a sequence of polymers of hydrogen cyanide. This starts forming loops at the fourth polymer stage. With five carbons it forms double loop compound known as adenine.

Both formaldehyde and hydrogen cyanide are very poisonous. In contrast to this, a compound of pentose sugar and adenine with three phosphate radicals (adenosine tri-phosphate, known as ATP) plays a vital role in transporting chemical energy in the cells of living organisms. Adenine and a slightly modified pentose sugar are key components of molecules of DNA which provide the genetic information for all living organisms.

These two polymerisation sequences provide excellent examples of how relatively simple things can come together to form more complex entities that have very different characteristics. And, in this particular case, these entities can also contribute to a further level of complexity, involving other compounds, to form the famous double helix of the DNA molecule. As with the simple gliders in Conway's Game of Life (see Box 2a) the individual entities are transformed and lose their identities. Also common ground with cellular automata is that the rules, in this case the number of bonds that each element can make, relate only to its immediate neighbours while the characteristics of the complex compound depend on the whole of its structure. **Complexity emerges spontaneously from simplicity and the whole is more than the sum of its parts.**



Box 13 shows just two base pairs of the spiral ladder that makes up the DNA molecule. The human genome contains about 3 billion base pairs organised into between 20 and 25,000 genes, located in 23 chromosomes. Complete copies of the entire genome occur in most of the cells of the human body of which there are in the order of ten million million. There are about 230 different types of cells which are organised into tissues which are in turn organised into organs which form systems which together form the complete body. The human body represents a level of complexity which is totally unimaginable simply in terms of its structure, let alone its dynamics. Yet it can be visualised, in terms of systems, as layer upon layer of things coming together. Starting with such simple processes as the polymerisation of formaldehyde to form more complex compounds, these come together to form macromolecules, macromolecules come together, uniting and transforming, to form organelles. And, through the same processes of coming together, uniting and transforming the systems pass through a sequence of levels of increasing complexity, of cells, tissues, organs and finally the complete living body. At each level the wholes, the complex realities, represent more than the sums of the parts that come together.

It is not surprising that Whitehead was inspired to claim that, “Creativity is the universal of universals ... It lies in the nature of things that the many enter into complex reality.”

The value of cellular automata is that they illustrate ways in which things can come together to form complex realities without the need to invoke the concept of design. Given the right conditions, molecules of formaldehyde polymerise spontaneously. Free formaldehyde has been detected in space, in interstellar gas clouds which are found in the Milky Way galaxy. These clouds also contain carbon monoxide and ammonia which can react together to form hydrogen cyanide. It is very probable that both compounds together with other possible building blocks of living things were included in the things that came together to form the complex reality of the early earth.

The behaviour of cellular automata, coupled with the above examples, demonstrate the possibility of spontaneous creativity. We do not need to seek a cause for how things are made, given the potential within a system, things quite simply make themselves.

Postulating the absence of design presents a problem for systems in the natural world. In the absence of any form of intentionality there are no internal means of differentiating between possible outcomes. With the cellular automata, the obvious value judgements involved in selecting the particular games illustrated in Boxes 2 to 9 were made outside the systems by an observer. For many of the systems that exist in the natural world the potential number of possible outcomes can be enormous. In the realm of living things, given genomes in the order of a billion base pairs, the number of possible permutations that could be associated with viable organisms is truly astronomical and far greater than the highest estimate of the number of species that have ever lived.

At the same time, the contexts in which systems exist in the natural world are complex and systems are faced with problems of survival which do not exist in the realm of the cellular automaton – Langton’s Ant never dies.

Whitehead claims that, “The salvation of reality is its obstinate, irreducible, matter-of-fact entities, which are limited to be no other than themselves... That which endures is limited, obstructive, intolerant, infecting its environment with its own aspects. But it is not self-sufficient. The aspects of all things enter into its very nature... Conversely it is only itself by lending its aspects to this same environment in which it finds itself.”

There is more to creativity than things simply making themselves. They also have to survive in their contexts. A way of looking at systems from the point of view of their survival is considered in the next section.

## That Which Endures

*Everything, in so far as it is in itself, endeavours to persist in its own being.*

Baruch Spinoza. *Ethics*. Part III, Proposition VI.

The word endeavour is a translation of the Latin *conatus* which carries connotations of effort, exertion, striving. The element of effort and striving is based on the everyday experience of what happens to things. They break and wear out, animals and plants die, rocks are worn away, and yet things endure. The term *conatus* has come to represent that which is responsible for the fact of the endurance of things, however ephemeral that endurance may be.

Spinoza offers the following proof of his proposition:

“Individual things are modes whereby the attributes of God are expressed in a given determinate manner that is, they are things which express in a given determinate manner the power of God, whereby God is and acts; now no thing contains in itself anything whereby it can be destroyed, or which can take away its existence; but contrariwise it is opposed to all that could take away its existence. Therefore, in so far as it can, and in so far as it is in itself, it endeavours to persist in its own being. *Q.E.D.*”

It has to be realised that for Spinoza, God and Nature are synonymous.

The key phrase in Spinoza’s proposition is, “*in so far as it is in itself*”. This suggests that where there is an internal dynamic or an internal relationship that has a measure of autonomy then there is the seat of *conatus*. If there is something inside that is not directly caused by something outside or at the very least has a non-linear relationship with whatever is outside – there is *conatus*.

A number of things follow from this. First and foremost, *conatus* is a verb, so the concept of *conatus* carries the implication of active process. Things do not just sit there and BE, they actively endeavour to persist in BEING. Secondly, the concept of *conatus* is a very general principle. In practice there are probably as many different forms and degrees of *conatus* as there are different things and entities. The *conatus* of a hydrogen atom is related to the attractive force between opposite electro-magnetic charges. There is a negatively charged electron orbiting round a positively charged proton and external energy is needed to remove the electron from its proton. The Hydrogen atom endeavours to persist in its own being. Hydrogen atoms prefer to go around in pairs forming a molecule. The Hydrogen molecule has its *conatus*. Hydrogen molecules rather like linking with an atom of oxygen to make water. Each molecule of water has its *conatus*. In both cases the molecule is the more stable state involving reduced energy levels. In the liquid phase, water molecules attract each other (see Box 14). There are internal relationships within liquid water which are manifest in the phenomenon of coherent flow. In the *conatus* of liquid water we have the first glimmerings of an explanation of Valentine's waterfall.

The *conatus* of living things is clearly of a different kind. Many living things possess systems that are primarily concerned with *conatus* and are connected with a will to survive. Nearly all living organisms react in such a way as to avoid or mitigate conditions that might be harmful. In the human and probably some other animals *conatus* has entered the self-conscious field. Not only do we wish to survive, we know that we wish to survive.

It would seem that one or other form of *conatus* is a feature of "that which endures". But Whitehead recognises that *conatus* is not enough, "That which endures is limited,... But it is not self-sufficient. The aspects of all things enter into its very nature... Conversely it is only itself by lending its aspects to this same environment in which it finds itself." Endurance necessarily involves interacting with the outside as well as persisting on the inside. At the very least, all complex dynamic systems need an external source of energy.

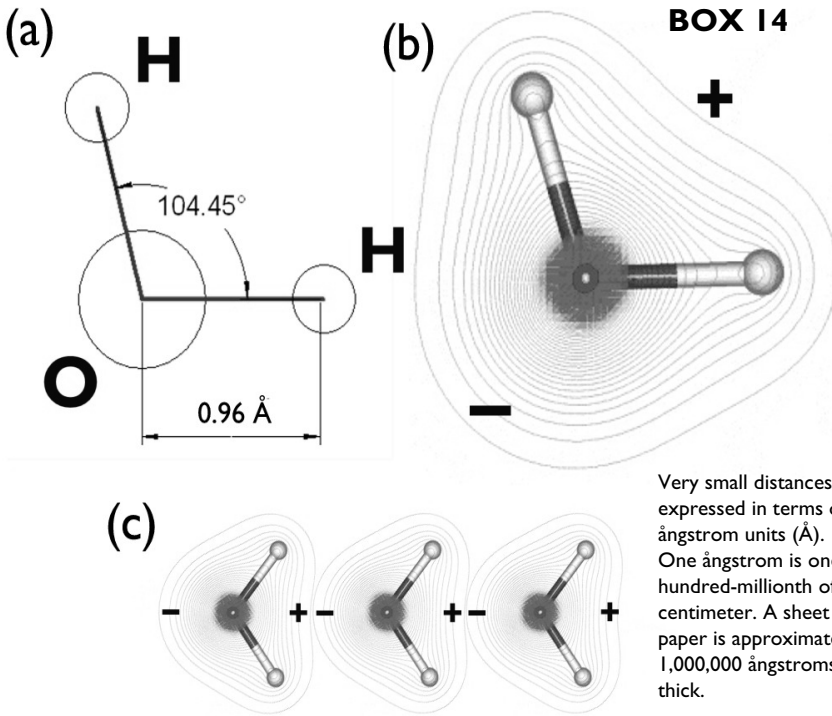


Diagram (a) is a schematic representation of a molecule of water containing two atoms of hydrogen (H) and one of Oxygen (O). They are arranged so that the two hydrogen atoms are at an angle of  $104.45^\circ$  with respect to the oxygen atom. The distance between the centres of the oxygen and hydrogen atoms is slightly less than 1 ångstrom (see inset box).

In a molecule of water each of the hydrogen atoms shares an electron with the oxygen atom. In effect these electrons spin in complex orbits within the molecule, but they tend to spend more time near the oxygen than either of the hydrogens. This is indicated by the density of the contour lines in diagram (b). Since the electrons carry a negative charge, the molecule of water is polarised, carrying a small positive charge near the hydrogen atoms and a negative charge near the oxygen atom. This means that the molecules of water will attract each other as shown in diagram (c). In liquid water the molecules are in constant motion relative to each other but the attraction due to the polarisation of the molecules imparts a level of coherence to the water in the mass. From this stems most of the properties of liquid water, how drops form, the smooth and turbulent flows in rivers and streams, over water falls and through pipes. The physics of fluid dynamics is one of the more complicated areas of the properties of things in the material world.

Again at the very least, the energy is needed to maintain the *conatus* of the system. Complete autonomy is not possible in the universe in which we exist.

As a complement to *conatus* the philosopher Freya Mathews has suggested the term *orexis*, which is “etymologically derived from *orektos*, meaning ‘longed for’ or literally ‘stretched out for’. *Orexis* may thus be taken to connote a condition of longing for contact with reality, a longing that may be expressed via many modalities.” This echoes Whitehead’s statement about the interdependence of things. There is a sense in which a hydrogen atom ‘reaches out’ to form an association with another atom to form a molecule. The *orexis* of a human embraces all the physical (eating, breathing) and sensory (seeing, talking) relationships and exchanges with the environment. You can think of *conatus* as looking inward and *orexis* as looking outward and in this sense they are opposites. *Conatus* is related to being closed off from the rest of the world; *orexis* is related to being open to it. Both concepts refer to dynamic processes and one cannot exist without the other. Nothing can exist in total isolation from the rest of the universe; equally, nothing can maintain its integrity in total openness.

As both *conatus* and *orexis* are essentially dynamic processes they can be visualised in terms flows of energy and/or information, with information playing an increasing role in more complex systems such as living organisms. The flows are internal in the case of *conatus* and in the form of exchanges with the environment in the case of *orexis*.

The qualities of *conatus* and *orexis* impose constraints on the way things have to be that were not relevant to the pseudo-universes of cellular automata. The cellular automata highlight the possibility of spontaneous creativity. Things make themselves without invoking either causality or a designer. The qualities of *conatus* and *orexis* begin to address the question of why there are some things and not others. It has to be in the nature of things which endure that they endeavour to persist in their own being and in order to maintain this endeavour, things have to enter into exchanges of some or all of matter,

energy and information with their environments – with the contexts in which they exist. *Conatus* and *orexis* are minimum requirements for survival in the real world.

The final step in the saga of creativity involves Whitehead's condition that a thing "is only itself by lending its aspects to this same environment in which it finds itself."

## That Which Fits

The phenomenon of *orexis* implies exchanges between entities and their environment. But the environment consists of other entities also exhibiting *orexis*. The result is a complex nexus of interactions and exchanges in which there is the possibility for interference, involving interactions that can be positive or negative or neutral. Living things provide examples of many forms of interaction of which the most obvious are competition for common resources, eating, and being eaten; but there are also many example of symbiosis, of living together to mutual advantage. In general, for things to survive they have to fit in to their environments, recognising that at the same time, things are parts of their own environments.

Things can make themselves spontaneously. In order to endure, things have to exhibit the features of *conatus*, a striving to persist, coupled with *orexis*, reaching out to the environment, to provide the means of exercising *conatus*. In order to endure and survive in the real world the elements of *orexis* have to exhibit a measure of compatibility with those of the things around them. We have come a long way from the simple universes of the cellular automata. We are equally quite a long way from ascribing purpose and design simply on the grounds of ordered structure. Paley's watch, found lying in the open, was certainly driven by clockwork which would soon run down. Exposed to the elements it is likely that the mechanism of the watch would deteriorate and cease functioning. To be complete, the watch has to exist in an appropriate environment, both for its very survival but also to fulfil its purpose of enabling its owner to tell the time. A thing cannot be separated from its environment,

“The aspects of all things enter into its very nature... Conversely it is only itself by lending its aspects to this same environment in which it finds itself.” Things also contribute towards creating their environments.

This situation is not too difficult to visualise with respect to individual entities, Paley’s watch for example, but the web of possible interactions between more than a relatively few things soon defies anything but a very generalised conception. There is no analytical solution to the equations describing the motions of just three bodies in space, where their *orexis* is defined entirely by the force of gravity. And yet, looking at the totality of the solar system, there is harmony. The orbits of the planets around the sun are sufficiently constant for long term predictions to be made about their positions. The solar system is essentially a closed system. Most terrestrial systems that are part of human experience – Valentine’s daffodils, clouds and waterfalls – are open to outside influences, their environments are not constant. At the same time there is harmony of a kind. Clouds produce rain which keeps waterfalls flowing, waterfalls erode rocks producing silt that contributes to the formation of soils in which daffodils can grow, daffodils transfer water from the soil to the atmosphere which can feed clouds. There is harmony but, as in these examples, the processes can and do operate on very different scales of both time and space. The flow of a waterfall is not dependent on a single cloud but on the complex dynamics of large weather systems which operate on a hemispheric if not global scale and which involve elements exhibiting chaotic behaviour. The phenomena of order and chaos are operative in the field of interactions between things as well as in their creative emergence. The key to the survival of things is that they contribute towards the creation of their own environments, a thing “is only itself by lending its aspects to this same environment in which it finds itself.” In effect, things become parts of higher order systems, which if they are to endure have to exhibit the features of *conatus* and *orexis*. We move from daffodils to forests, from waterfalls to landscapes, and from clouds to weather.

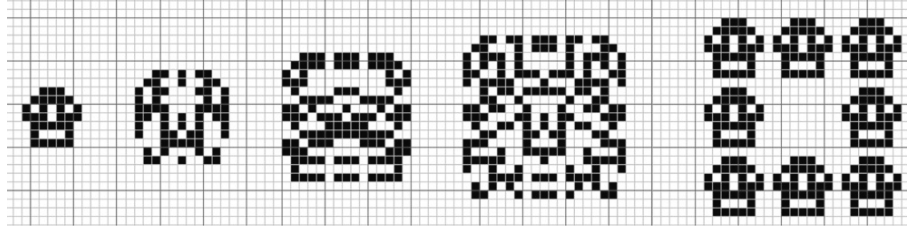
In her novel *The Poisonwood Bible*, Barbara Kingsolver paints a portrait of a forest, “The trees are columns of slick, brindled bark like muscular animals

overgrown beyond all reason. Every space is filled with life: delicate, poisonous frogs war-painted like skeletons, clutched in copulation, secreting their precious eggs onto dripping leaves. Vines strangling their own kin in the everlasting wrestle for sunlight. The breathing of monkeys. A glide of snake belly on branch. A single-file army of ants biting a mammoth tree into uniform grains and hauling it down to the dark for their ravenous queen. And, in reply, a choir of seedlings arching their necks out of rotted tree stumps, sucking life out of death. This forest eats itself and lives forever.”

Things come together, trees, frogs, vines, monkeys, snakes, and ants, to form a new complex reality – the forest, which has its *conatus*, “it eats itself and lives for ever.” It also has its *orexis*, it modifies its own landscape and up to a point its own weather. At the same time, the things that come together to make the forest maintain their individual identities. They also interact to create a new environment which provides opportunities for new things to create themselves.

In this way creativity begets creativity. But, in addition to the making, there is also a rigorous process of selection. In order to survive, things have to exhibit *conatus* and *orexis* and these have to demonstrate a measure of compatibility with the things that already constitute the environment. It is the combination of making and selection that constitutes the creative process – that which endures coupled with that which fits.

Natural selection operates throughout the natural world, and is not confined to the dynamics of living organisms. Charles Darwin was concerned that his phrase ‘natural selection’ was being interpreted by some as implying the existence of an external something doing the selecting. In the 5<sup>th</sup> edition of *The Origin of Species* (1869) he added the phrase ‘the survival of the fittest’ which he borrowed from the philosopher Herbert Spencer (in his *Social Statics*, 1851) in an attempt to clarify what he was proposing in his theory. A phrase which perhaps expresses the reality better than either of these is ‘the survival of that which fits best’.

**BOX 15**

Living things exhibit a number of features which, while still involving the concepts of *conatus* and *orexis* coupled with selection, can be regarded as adding an extra dimension to the creative process. Most significant is that living organisms can reproduce themselves. Moreover the methods by which organisms do this involves the possibility of introducing a measure of variability. In most natural means of reproduction, offspring resemble but are not identical to their parent or parents. Crucially, and in general, the causes of the variability are independent of the life cycle and way of life of the organism and are related to random phenomena.

There are analogues within the field of cellular automata. In particular, there is a rule for Conway's Game of Life (see Box 15) for which the initial pattern reproduces itself in an ever expanding array. But it can only reproduce itself exactly. The only way to introduce variability for a given initial state is to change the rule. And given the relative simplicity of the rules any change completely alters the behaviour of the system.

The real game of life is incredibly more complicated. Richard Lewontin speaks of the triple helix of gene, organism and environment, three elements inextricably entwined in the creative processes that result in a complete individual that in turn participates in the creation of the next generation of organisms. The individuals of this next generation will be slightly different and may vary with respect to the quality of their compatibility with their environments which may in turn affect their ability to reproduce. This process repeated, generation after generation is the process by which organisms create themselves, and this is how Valentine's daffodil emerged.

## Constraint

*Without a system of formal constraints there is no creativity, there is only change.*

Noam Chomsky.

Noam Chomsky was thinking in terms of language, that what differentiates language from a meaningless babble of sound are the systems of associating sound with meaning, involving constraints imposed by the rules of grammar and syntax.

The role of constraint in contributing to the generation of order has already been recognised in relation to the behaviour of Langton's Ant (see p. 30) but it needs to be considered in more detail. The dialectic of order and chaos can provide a conceptual scheme, complementary to *conatus* and *orexis*, for visualizing creative processes.

Humans tend to have a problem with the thought that there are constraints to aspirations. At the end of the film of H. G. Wells' story *Things to Come* one of the characters asks "Is there never to be any rest?" to which the hero of the story replies, "rest enough for the individual, too much and too soon; we call it death. But for mankind, no rest and no ending, he must go on – conquest beyond conquest – first this little planet and its winds and waves, and then all the laws of mind and matter that restrain him, and then the planets above him – and at last out across the immensities of space to the stars; and when he has conquered all the deeps of space and all the mysteries of time, he will still be beginning. All the Universe or nothing – which shall it be, which shall it be?"

We tend to see constraints as limiting our freedom to act and as something to be overcome. There is a profound paradox here because we accept and expect, in fact depend on, order and regularity in the non-human world. Try to think for a moment of what it would be like to exist in a world in which there were no constraints, in which absolutely anything could happen anywhere and at any time to any thing. For there to be any kind of meaningful existence the world has to be substantially ordered and constrained by laws. But, also try to think of a world which is totally ordered, a world synonymous with Paley's watch. It is a world that has been created, but in which no further creation is possible. The things of the real world have to exist in a space somewhere between the totally chaotic and the totally ordered.

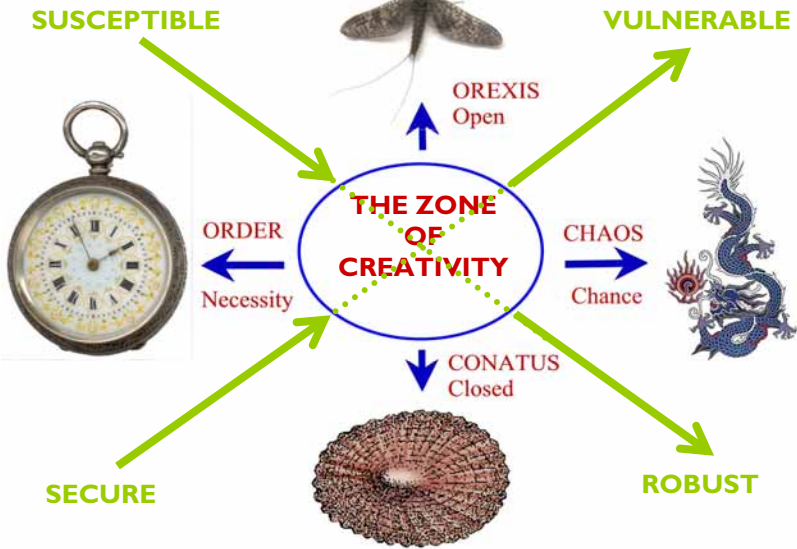
The systems theorist Stuart Kauffman is primarily concerned with the nature of living organisms but he suggests, as a potential general law, that "the best exploration of an evolutionary space occurs at a kind of transition between order and disorder". He coined the term 'the edge of chaos' to describe this situation. The beauty of Langton's Ant is that one can see the transitions between order and chaos, both of which are constrained by the rules but with order coming into being at the edge of the pattern where there is the additional constraint that the ant is more likely to walk onto a white square than it is when away from the edge. Kauffman's use of the word 'edge' is surely figurative but in practice edges and surfaces can play a significant role in the field of creative constraint. In heated water bubbles first appear on the surface of the container. And at the macro scale, most living things exist at, or close to, the interface between the earth and the atmosphere.

Possibly the most fundamental constraints are associated with the conservation laws. These state that matter and energy can neither be created nor destroyed, they can only be transformed. Clearly the conservation laws are very powerful and fundamental ordering principles. If matter and energy can only be transformed it follows that the state of the universe at any time has to be a function of the state of the universe at the immediately previous moment of time. The universe behaves as an iterated algorithm, but one which does not have an analytical solution. Future states of the universe are inherently unpre-

dictable. In large measure this is due to transitions between order and chaos, and their co-existence can be considered to be a function of the conservation laws. The existence of these laws would seem to be a necessary condition for anything we could even begin to call creative.

Another constraint that has been extensively studied in the context of the dynamics of systems is the second law of thermodynamics. This is the law that deals with energy flows and it states that within a closed system energy flows in a way that renders it unavailable for useful work. It is this law that constrains systems to exhibit a measure of openness to their environments to provide an ongoing source of energy necessary for the maintenance of *conatus*. This requirement is a key element in the *orexis* of systems. It seems to be the case that the energy flow through systems increases with increased complexity. A measure of energy flow per unit mass of a system has been proposed as providing a comparative and quantitative measure of the complexity of systems.

It would seem possible to combine the dialectics of order and chaos, and of *conatus* and *orexis* into a single two dimensional phase space representing the states of all possible entities. If we assume the two dimensions are orthogonal then the system can be represented as shown in Box 16. The extreme points of each dimension are represented by symbolic examples: extreme order by what might be Paley's watch; extreme chaos by a dragon, which is often used as a symbol of disorder; extreme *conatus* by a limpet which clings to its rock seemingly closed to the rest of the world; extreme *orexis* by a mayfly, which lives in this form for a few hours only and whose sole purpose is looking outwards to find another mayfly to mate with. In fact, both the mayfly and the limpet have stages in their life cycles that are located elsewhere in the phase space. The limpet produces very large numbers of small ephemeral motile larvae whose function is to find some other rock on which to settle. The larvae of mayflies live for the best part of a year, sometimes longer, concealed in the mud or hidden under stones at the bottom of a stream, river or pond.

**BOX 16**

In the centre is the zone of creativity. This is the area of the phase space occupied by everything that can both create itself and survive. Or rather, every single entity will exist within its own particular phase space, in which the size and probably the shape of the creative zone will vary. What is presented here is a very generalised scheme. However, it may not be asking too much to propose that, in addition to the two main dimensions, there are also diagonal dimensions (shown in green in the diagram). An entity that tends to be open and ordered will be easily damaged and may cease to function. A system that tends to be closed and chaotic may be able to cope with interference, it will tend to be robust. A system that is closed and ordered will fairly obviously be secure while one that is open and chaotic will definitely be vulnerable.

Box 16 represents the beginning of the process of synthesis, of attempting to bring together the aspects and conditions of creativity to provide the beginnings of the story of how nature creates itself.

# Emergence

## Putting it all together

*There is no doubt that biological features and phenomena are rooted in physico-chemical processes of the molecules involved; and yet, systems of components have features that the components themselves do not have, and which cannot be derived from elementary component properties in an algorithmic manner that could be automated. Top-down approaches are necessary as well; integrated systems aspects are becoming more and more relevant not only in developmental biology, but also in brain and behavioral sciences... Theoretical biology is expected to be increasingly involved in progress in these fields.*

Hans Meinhardt and Alfred Gierer

*Emergence means complex organizational structure growing out of simple rules. Emergence means stable inevitability in the way certain things are. Emergence means unpredictability, in the sense of small events causing great and qualitative changes in larger ones. Emergence means the fundamental impossibility of control. Emergence is a law of nature to which humans are subservient.*

Robert Lauchlin. *A Different Universe*

Pre-echoing Paley, Thomas Hobbes wrote, “Everything is best understood by its constitutive causes. For, as in a watch or some such small engine, the matter, figure and motion of the wheels cannot well be known except it be taken asunder and viewed in parts.”

In contrast to this, the fundamental premise relating to emergent phenomena is that wholes can contradict Hobbes’ dictum and be more than the sums of their parts. In any system for which this is true, that element which constitutes the ‘more than’ is an emergent property of the whole system. Emergent phenomena cannot be described in terms of a chain of causality.

There is no external force or influence that causes the watch to tell the time, it is an inherent property of the whole system. Emergent phenomena do not have a cause, they just happen, and as such have to be regarded as the outcomes of a creative processes.

If you know that a watch tells the time then, retrospectively, you can describe how it does so by taking it asunder and viewing it in parts. But no analysis of the parts will tell you that a watch is for telling the time. No analysis of the properties of the elements hydrogen and oxygen will tell you about the properties of water.

There is a similar problem with the property of solidity. In the whole universe solid matter is relatively uncommon. But as far as the earth is concerned, solid matter is an integral part of practically everything that constitutes our daily experience. And yet, when you take solids apart and view their parts at the level of atoms than the whole concept of solidity vanishes. For neutrinos, solidity hardly exists, some five million neutrinos pass through every square centimeter of our bodies every second as if they were not there. Nevertheless, the emergent phenomenon of solidity is real and is as much a fundamental aspect of reality as are the properties of the so-called fundamental particles which constitute solid objects.

With respect to the emergent phenomena associated with the phases of matter, that is gases, liquids and solids, Robert Lauchlin says, “By far the most important effect of phase organisation is to cause objects to exist. This point is subtle and easily overlooked, since we are accustomed to thinking about solidification in terms of packing of Newtonian spheres. Atoms are not Newtonian spheres, however, but ethereal quantum-mechanical entities lacking that most central of all properties of an object – an identifiable position... It is aggregation into large objects that makes a Newtonian description of the atoms meaningful, not the reverse.”

Emergent phenomena in general are the result of collective properties involving forms and patterns of relationship between entities. What Lauchlin is emphasizing is that with respect to the phase organization of matter, not only

is a whole more than the sum of its parts but also the interrelationships between the parts contributes to their reality. Whitehead again, “Conversely [a thing] is only itself by lending its aspects to this same environment in which it finds itself”. The most significant contribution of the parts to a whole is the ability to make the relationships with each other that lead to the emergent properties of the whole.

In the field of emergent phenomena it is necessary to think in terms of successive levels of reality. Each level has its aspects which have to be regarded as fundamental to the phenomena characteristic of the particular level. Forests exhibit emergent properties based on relationships between living organisms. Equally it is the emergent properties of the forest that provide the context for the evolution of the organisms that constitute the forest. Living organisms show emergent properties based on relationships between complex chemicals. Complex chemicals show emergent properties based on the relationships between atoms. Atoms show emergent properties based on the relationships between sub-atomic particles. In each case, there is a sense in which it is possible to say that emergence works both ways, from parts to wholes and from wholes to parts.

Box 16 presents an analytical framework for the relationships between entities and their environments in terms of order, chaos, *conatus* and *orexis*. The implication is that the zone of creativity is also the zone of emergent phenomena. But it begs the question as to whether all emergent phenomena can be regarded as involving creativity. The temperature of a gas is an emergent property of the collective behaviour of its constituent molecules. It is a function of the statistical average of the velocities of the individual molecules that constitute the gas and these will exhibit substantial variability. In general, temperature involves an element of disorder. In contrast to this the emergent properties of adenine (see Box 12) depend crucially on the precise, ordered relationships of its atoms. Its synthesis, however, involves the transformation of the parts that come together. Their *conatus* is submerged. The temperature of a gas and the properties of adenine are both emergent phenomena which result from things coming together to form a complex reality. While the emergence of adenine

can clearly be considered as resulting from a creative process, the temperature of a gas is not normally considered to be so. And yet both are clearly involved in the process of how nature creates itself. Consider the role that the temperature of the atmosphere plays in the dynamics of the earth, in shaping the climate of the earth and in the nature and distribution of living things.

It is difficult to devise any rational criteria whereby adenine is regarded as the result of creativity and temperature is not. At the very least we have to acknowledge that variations in the temperature of the earth's atmosphere, and many other manifestations of variations in temperature, play a significant role in the processes by which nature creates itself. In a world in which all things are connected, in which complete autonomy is not possible, the contexts and environments of creative events are involved in the creativity. Perhaps we have to broaden our ideas about creativity to embrace all emergent phenomena.

One of the concepts that has been useful in attempts to give shape to studies of emergent phenomena is that of symmetry. In the scientific definition of symmetry the surface of a still body of water exhibits perfect two-dimensional symmetry because it is the same in all possible directions in a two dimensional plane. If you drop a stone into the water the result is the emergent phenomenon of a set of circular ripples which are symmetrical about a centre (the point where the stone was dropped); these ripples exhibit radial symmetry in that they look the same in all directions, but only from the central point. They exhibit a reduced symmetry compared with that of the undisturbed surface. In general, increase in order and pattern is associated with broken symmetries. In Box 6 diagram (a), the probability that a square will show a particular colour is equal for all the squares, and in this sense the pattern exhibits symmetry. Diagram (b) shows a clearly ordered pattern and thus exhibits a broken symmetry compared with diagram (a).

The association of emergence with symmetry breaking comes into its own in looking at the very early history of the universe. It is now generally accepted that one of the events associated with the initial singularity of the Big Bang was the emergence of matter and energy from some common precursor. Emergence through symmetry breaking provides a conceptual scheme for

visualising this event. Entering more speculative territory it can be conceived that the initial singularity exhibited a form of perfect symmetry and that all phenomena emerged from this by processes of symmetry breaking, including the dimensions of space and time as well as matter and energy and the natural forces. In this context the conservation laws are themselves emergent principles and can be considered to have emerged through a process of symmetry breaking.

However close to the initial singularity of the Big Bang one is prepared to accept creation by emergent symmetry breaking, there can be no doubting the significance of emergent processes in the rest of the creation story.

All of the building blocks of the universe were in place within a relatively short period after the beginning of time. The universe that we now see and experience has formed itself by an evolutionary sequence of rearrangements of relationships between these same building blocks through the emergence of novel properties. These are the result of particular patterns of relationship. They lead to an ever growing variety of modes of existence determined by the nature of the relationship capable of being established by the entities involved and subject to forms of constraint and processes of selection. To quote Valentine, "The unpredictable and the predetermined unfold together to make everything the way it is. It's how nature creates itself."

## Edges, Constraint and Symmetry Breaking

Edges and surfaces necessarily imply broken symmetry. Edges and surfaces are also associated with forms of constraint because of the broken symmetry. Does it follow that all broken symmetries are associated with constraints in the form of positive limitations?

The role of surfaces and boundaries is nowhere more significant than in the structure and functioning of living organisms. This is obvious in the case of the epidermal layers (the outer 'skin') of virtually all living organisms, which play a key role in their *conatus*. There are also many different kinds of membranes exhibiting asymmetric permeabilities to just about everything that is involved in the process of life. They are largely responsible for maintaining the ordered patterns of differentiation within organisms without which complex life forms could not exist. There are membranes round the nuclei of cells which play a role in maintaining the integrity of the cell's genome. There are membranes forming the boundaries of each and every cell which give the cells a measure of autonomy as separate living entities. At the same time these membranes are permeable to the substances necessary for the metabolism and growth of the cell. They are simultaneously barriers and selective gateways.

Is it possible to generalise from the role of surfaces in the processes of life and see surfaces (and broken symmetries?) acting simultaneously as constraints and opportunities?

Going to the other end of the scale of things, if it is accepted that the conservation laws are the result of an emergent symmetry breaking then such generalisation begins to look possible. In this case the surface is the boundary between matter and energy. There is little doubt that the conservation laws provide an excellent example of constraints within which there are seemingly limitless opportunities for the emergence of forms of being.

## Epilogue

*The history of the cosmos is the history of the struggle of becoming.*

D. H. Lawrence

### Valentine revisited

“The unpredictable and the predetermined unfold together to make everything the way it is. It’s how nature creates itself, on every scale, the snowflake and the snowstorm. It makes me so happy. To be at the beginning again, knowing almost nothing... The ordinary-sized stuff which is our lives, the things people write poetry about – clouds – daffodils – waterfalls ... these things are full of mystery...”

The idea of creation by emergence developed in the previous sections provides added weight to Valentine’s talk about nature creating itself through a process of unfolding. If we define a story as the trajectory of a system through time then the unfolding can be likened to turning over a page in a novel to find out what happens next. Whatever it is, it has to follow on from what has gone before, but what it will say is unknown to the reader. The difference in the real world is that the new page is blank. As Ilya Prigogine points out, “Time is creation. The future is just not there”. The story has to write itself, word by word, as if the story works like an iterated algorithm with parameters provided by the rules and conventions of the written language.

Nature’s story is more complicated. There is a whole series of nested stories, of systems within systems. There is a molecular story, and a phase structured story (based on the existence of solids, liquids and gasses). For Valentine’s cloud there is weather system story. For the waterfall there is a

river story and a landscape story. For the daffodil there is a life story and an ecosystem story. For all three, there is a Gaia story. And the stories can be extended in both directions to embrace both the very big and the very small. At each successive level the stories become more elaborate and each story has its own language and its own rules of grammar and syntax. The stories at successive levels have to be conformable without being predictable.

Differentiation of stories into levels is a useful aid to visualization but it is also misleading. The daffodil story is determined not only from bottom up, involving its evolutionary history (the life story) but also from the top down involving the ecology of woodlands (the ecosystem story).

Where Valentine talks of the need for a new beginning and of knowing almost nothing, he is referring to the traditional dominance of reductionism in the sciences. The Hobbesian reductionist methodology of taking things apart to find out how they work leads to reductionist thinking – the place of things in the world was considered almost exclusively from a bottom up perspective. The new beginning involves much more top-down thinking, and seeing things in a perspective of layered stories. The views of things from the perspective of the still relatively young earth sciences, of ecology, geology, meteorology and oceanography, have only recently achieved equal status to those from physics and chemistry. In particular, the recent emergence of the Gaia story, initiated by Vladimir Vernadski in the 1920's and subsequently developed by James Lovelock and Lynn Margulis, is an essay in top down views of the earth system.

Gaia theory and the earth sciences substantially relate to emergent phenomena. They can be seen essentially as studies of how nature creates itself.

Valentine's invocation of a sense of mystery in relation to the existence of, "the ordinary-sized stuff which is our lives, the things people write poetry about" is fully justified. And the analysis of natural creativity attempted in this essay, while opening a few windows, has done so only by revealing further mysteries calling for an ever deeper sense of wonder and amazement.

## William Paley revisited

In the light of the analysis of natural creativity presented here it would seem that Paley's interpretation of order and design as necessarily being the work of an external creator is no longer tenable. Complexity, order and the appearance of design can emerge spontaneously from chaos and from systems governed by simple rules, even in the very simple universes of the cellular automata.

In response to Keith Ward's claim, in relation to how things come to be, that 'the theistic hypothesis is a better one than the materialist hypothesis, because it makes the existence of a universe like this very much more probable than materialism does,' what emerges from this study suggests a measure of convergence between the two hypotheses. If nature creates itself, then creativity has to be intrinsic to matter, but this does not necessarily imply strict materialism.

Keith Ward's statement that the theistic hypothesis provides the basis for confidence in the intelligibility of the world, has to be questioned. There is no doubt that the world is intelligible up to a point. But, much of the analysis presented here has to be regarded as descriptive rather than explanatory. There is the logical problem highlighted by Max Planck, "Science cannot solve the ultimate mystery of Nature. And it is because in the last analysis we ourselves are part of the mystery we are trying to solve". But also there is the tendency to make God conform to human expectations. Anne Primavesi says that the confines within which we place and then describe God are all on our side of the horizon. She speaks of the need to "give God room: room to be God of the whole earth system: enchanting and terrible, giver of life and death."

We can only view the panorama of creation from 'our side of the horizon' and in so far as it is possible, it has been beautifully encapsulated by Annie Dillard.

"Certainly nature seems to exult in abounding radicality, extremism, anarchy. If we were to judge nature by its common sense or likelihood, we wouldn't believe the world existed. In nature, improbabilities are the one stock in trade. The whole creation is one lunatic fringe. If creation had been left to me,

I'm sure I wouldn't have had the imagination or courage to do more than shape a single, reasonably sized atom, smooth as a snowball, and let it go at that. No claims of any and all revelations could be as far fetched as a single giraffe....

“Intricacy is that which is given from the beginning, the birthright, and in intricacy is the hardness of complexity that ensures against the failure of all life. This is our heritage, the piebald landscape of time. We walk around; we see a shred of the infinite possible combinations of an infinite variety of forms.

“Anything can happen; any pattern of speckles may appear in a world ceaselessly bawling with newness... The wonder is – given the errant nature of freedom and the burgeoning of texture in time – the wonder is that all the forms are not monsters, that there is beauty at all, grace gratuitous... Beauty itself is the fruit of the creator's exuberance that grew such a tangle, and the grotesques and horrors bloom from that same free growth, that intricate scramble and twine up and down the conditions of time.

“This, then, is the extravagant landscape of the world, given, given with pizzazz, given in good measure, pressed down, shaken together, and running over.”

## **Mother Carey revisited**

Reflecting on biological evolution the scientist and theologian Arthur Peacocke says, “we recognise now, more than ever before, that new modes of existence, new activities and new kinds of behaviour come into existence through the course of evolutionary time – and that we need new concepts and ways of investigating them. New kinds of realities appear: increasing complexity, information-processing, consciousness and finally, in humanity, self-consciousness. So, the believer in God can affirm, with even greater conviction than before, that God is the Continuous Creator. He is all the time creating – through the processes of nature which the biologist uncovers. God makes things make themselves. The splendid panorama of both cosmic and biological evolution should be a stimulus to worship and awe.”

Thomas Berry extends Arthur Peacocke's idea to the whole of the universe, "[the universe] is a reality, functioning from within its own spontaneity. It is so remarkable and so stupendous to come to understand this process. The divine enables the universe to function in this remarkable way. There is a capacity of self-articulation inherent in the universe, and the more we know about that, the clearer it is that we will gain a totally different sense of the universe than we had previously, and a different sense of how the divine functions in relation to the universe."

Both Peacocke and Berry echo Teilhard de Chardin in his eulogy of matter, "Blessed be you, universal matter... you who by overflowing and dissolving our narrow standards of measurement reveal to us the dimensions of God... I acclaim you as the divine *milieu*, charged with creative power..."

One possible way of visualising the divine with respect to how things come to be is to use the metaphor of emergence, that there is a sense in which the divine can be regarded as emergent in relation to the universe. The divine embraces the universe but there is the element that is 'more than'. Also, in the created order the process of emergence seems to work 'downwards' as well as 'upwards'. There is a sense in which a level of reality, as well as being the potential for the 'succeeding' level also contributes towards the reality of the 'previous' level. So, with respect to the element of the divine that is 'more than', we can say with Peacocke "God makes things make themselves", or with Berry "The divine enables the universe to function... from within its own spontaneity."

An idea of a relationship between God and the universe mediated through a process of emergence where the divine is manifest as both the potential and the outcome is close to the vision of process theology as described by Rosemary Radford Ruether:

"Process theology postulates... a dipolar God. The Primordial Nature of God contains the whole of potentiality of all existing entities at every moment of actualisation. This Primordial Nature of God provides the 'initial aim' or best potential option for each entity at each occasion of existence... Each entity has,

however, its own subjectivity. It adapts or actualises this aim of God through actualising one possibility that can only partially fulfil that aim, and can even thwart that aim in negative choices that are destructive... As entities opt for particular choices, these actualisations are taken into the being of God as God's Consequent Nature. The reality of God is thus shaped through interrelation with self-actualising entities. God not only lures and offers new life, but also suffers, experiencing the pain of destructive choices as well as the pleasure of good choices."

Within the contemporary scene there are strident voices claiming that there is an irreconcilable divide between the view of creation as the work of a super-natural divine being who acts as initiator and designer of all that is (creationism and intelligent design), and the view of creation as the result of natural evolutionary processes not requiring the involvement of any external power or being. Madeleine Bunting suggests that the two views feed off each other, the one claiming authenticity on the basis of the alleged errors of the other.

The view of natural creativity outlined in this essay points in the direction of a synthesis in which the matter of the universe is charged with creative power and is also the divine *milieu*. Creation is the result of natural evolutionary processes involving layer upon layer of creative transformation of what is already there, such that creativity begets creativity in a blend of spontaneity tempered by necessity. It is a process of essential simplicity but also one of breathtaking elegance. When we look at the outcomes – the magnificent and incredibly complex panorama of creation, we are faced with the problem of trying to work out how it happened. Also, as Thomas Berry points out, we have to come to a different sense of how the divine functions in relation to the universe.

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## APPENDIX I

## Rules for Langton's Ant

For readers who have access to the Ant-ology programme or who are willing to download it (at [http://fvdp.homestead.com/files/ant\\_index.html](http://fvdp.homestead.com/files/ant_index.html)), the rules for the patterns shown in Boxes 6 to 9 are given below.

The pattern in Box 6 is produced by:

$$7- 1+ 5- 4+ 4-$$

There several rules resulting in expanding triangular ordered sequences:

$$4+ 5- 5+ 7- 3+$$

$$4+ 5- 5+ 7- 7+$$

$$13+ 9- 1+$$

There are a number of rules that produce patterns like that in Box 7. Try starting with:

$$1+ 1- 1+ 1- 8+ 1- 1+ 1- 2+ 5- 21+$$
 and alter the number of final +s

The rule for Box 8 is:

$$11- 7+ 1-$$

For Box 9 try:

$$3- 3+ 2- 2+$$
 for the mainly chaotic pattern.

There are a number of rules which produce a round and round sequence. Try:

$$4+ 5- 5+ 1- 3+$$

$$5- 3+ 3- 9+ 1-$$

There is more about Langton's Ant at:

<http://www.greenspirit.org.uk/resources/Langton.htm>

## APPENDIX II

“the things people write poetry about – clouds – daffodils – waterfalls”

### The Cloud

I bring fresh showers for the thirsting flowers,  
 From the seas and the streams;  
 I bear light shade for the leaves when laid  
 In their noonday dreams.  
 From my wings are shaken the dews that waken  
 The sweet buds every one,  
 When rocked to rest on their mother's breast,  
 As she dances about the sun.  
 I wield the flail of the lashing hail,  
 And whiten the green plains under,  
 And then again I dissolve it in rain,  
 And laugh as I pass in thunder.  
 I sift the snow on the mountains below,  
 And their great pines groan aghast;  
 And all the night 'tis my pillow white,  
 While I sleep in the arms of the blast.  
 Sublime on the towers of my skiey bowers,  
 Lightning, my pilot, sits;  
 In a cavern under is fettered the thunder,  
 It struggles and howls at fits;

Over earth and ocean, with gentle motion,  
 This pilot is guiding me,  
 Lured by the love of the genii that move  
 In the depths of the purple sea;  
 Over the rills, and the crags, and the hills,  
 Over the lakes and the plains,  
 Wherever he dream, under mountain or stream,  
 The Spirit he loves remains;  
 And I all the while bask in Heaven's black smile,  
 Whilst he is dissolving in rains.

The sanguine Sunrise, with his meteor eyes,  
 And his burning plumes outspread,

Leaps on the back of my sailing rack,  
 When the morning star shines dead;  
 As on the jag of a mountain crag,  
 Which an earthquake rocks and swings,  
 An eagle alit one moment may sit  
 In the light of its golden wings.  
 And when Sunset may breathe, from the lit sea  
 beneath,  
 Its ardours of rest and of love,  
 And the crimson pall of eve may fall  
 From the depth of Heaven above,  
 With wings folded I rest, on mine acry nest,  
 As still as a brooding dove.

That orb'd maiden with white fire laden,  
 Whom mortals call the Moon,  
 Glides glimmering o'er my fleece-like floor,  
 By the midnight breezes strewn;  
 And wherever the beat of her unseen feet,  
 Which only the angels hear,  
 May have broken the woof of my tent's thin roof,  
 The stars peep behind her and peer;  
 And I laugh to see them whirl and flee,  
 Like a swarm of golden bees,  
 When I widen the rent in my wind-built tent,  
 Till the calm rivers, lakes, and seas,  
 Like strips of the sky fallen through me on high,  
 Are each paved with the moon and these.

I bind the Sun's throne with a burning zone,  
 And the Moon's with a girdle of pearl;  
 The volcanoes are dim, and the stars reel and swim  
 When the whirlwinds my banner unfurl.  
 From cape to cape, with a bridge-like shape,  
 Over a torrent sea,  
 Sunbeam-proof, I hang like a roof,—  
 The mountains its columns be.  
 The triumphal arch through which I march  
 With hurricane, fire, and snow,

When the Powers of the air are chained to my chair,  
Is the million-colored bow;  
The sphere-fire above its soft colors wove,  
While the moist Earth was laughing below.

I am the daughter of Earth and Water,  
And the nursling of the Sky;  
I pass through the pores of the ocean and shores;  
I change, but I cannot die.  
For after the rain when with never a stain  
The pavilion of Heaven is bare,  
And the winds and sunbeams with their convex gleams  
Build up the black dome of air,  
I silently laugh at my own cenotaph,  
And out of the caverns of rain,  
Like a child from the womb, like a ghost from the tomb,  
I arise and unbuild it again.

Percy Bysshe Shelley

### Daffodils

I wander'd lonely as a cloud  
That floats on high o'er vales and hills,  
When all at once I saw a crowd,  
When all at once I saw a crowd,  
A host, of golden daffodils;  
Beside the lake, beneath the trees,  
Fluttering and dancing in the breeze.

Continuous as the stars that shine  
And twinkle on the Milky Way,  
They stretch'd in never-ending line  
Along the margin of a bay:  
Ten thousand saw I at a glance,  
Tossing their heads in sprightly dance.

The waves beside them danced; but they  
Out-did the sparkling waves in glee:  
A poet could not but be gay,  
In such a jocund company:  
I gazed – and gazed – but little thought  
What wealth the show to me had brought:

For oft, when on my couch I lie  
In vacant or in pensive mood,

They flash upon that inward eye  
Which is the bliss of solitude;  
And then my heart with pleasure fills,  
And dances with the daffodils.

William Wordsworth

### The Cataract of Lodore

From its sources which well  
In the tarn on the fell;  
From its fountains  
In the mountains,  
Its rills and its gills;  
Through moss and through brake,  
It runs and it creeps  
For a while, till it sleeps  
In its own little lake.  
And thence at departing,  
Awakening and starting,  
It runs through the reeds,  
And away it proceeds,  
Through meadow and glade,  
In sun and in shade,  
And through the wood-shelter,  
Among crags in its flurry,  
Helter-skelter,  
Hurry-scurry.

Here it comes sparkling,  
And there it lies darkling;  
Now smoking and frothing  
Its tumult and wrath in,  
Till, in this rapid race  
On which it is bent,  
It reaches the place  
Of its steep descent.

The cataract strong  
Then plunges along,  
Striking and raging

As if a war raging  
Its caverns and rocks among;  
Rising and leaping,

Sinking and creeping,  
 Swelling and sweeping,  
 Showering and springing,  
 Flying and flinging,  
 Writhing and ringing,  
 Eddying and whisking,  
 Spouting and frisking,  
 Turning and twisting,  
 Around and around  
 With endless rebound:  
 Smiting and fighting,  
 A sight to delight in;  
 Confounding, astounding,  
 Dizzying and deafening  
 the ear with its sound.

Collecting, projecting,  
 Receding and speeding,  
 And shocking and rocking,  
 And darting and parting,  
 And threading and spreading,  
 And whizzing and hissing,  
 And dripping and skipping,  
 And hitting and splitting,  
 And shining and twining,  
 And rattling and battling,  
 And shaking and quaking,  
 And pouring and roaring,  
 And waving and raving,  
 And tossing and crossing,  
 And flowing and going,  
 And running and stunning,  
 And foaming and roaming,  
 And dinning and spinning,  
 And dropping and hopping,  
 And working and jerking,  
 And guggling and struggling,  
 And heaving and cleaving,  
 And moaning and groaning;

And glittering and frittering,  
 And gathering and feathering,  
 And whitening and brightening,  
 And quivering and shivering,

And hurrying and skurrying,  
 And thundering and floundering;

Dividing and gliding and sliding,  
 And falling and brawling and sprawling,  
 And driving and riving and striving,  
 And sprinkling and twinkling and wrinkling,  
 And sounding and bounding and rounding,  
 And bubbling and troubling and doubling,  
 And grumbling and rumbling and tumbling,  
 And clattering and battering and shattering;

Retreating and beating and meeting and sheeting,  
 Delaying and straying and playing and spraying,  
 Advancing and prancing and glancing and dancing,  
 Recoiling, turmoiling and toiling and boiling,  
 And gleaming and streaming and steaming and beaming,  
 And rushing and flushing and brushing and gushing,  
 And flapping and rapping and clapping and slapping,  
 And curling and whirling and purling and twirling,  
 And thumping and plumping and bumping and jumping,  
 And dashing and flashing and splashing and clashing;  
 And so never ending, but always descending,  
 Sounds and motions for ever and ever are blending  
 All at once and all o'er, with a mighty uproar,  
 And this way the water comes down at Lodore.

Robert Southey

*The Falls of Lodore are in the Lake District and are part of  
 Watendlath Beck as it tumbles into Borrowdale before emptying  
 into Derwent Water.*

## Other GreenSpirit Titles

*GreenSpirit: Path to a New Consciousness* (published by Earth Books). Edited by Marian Van Eyk McCain. Features contributions from twenty-nine inspirational writers, including Matthew Fox, Brian Swimme, Satish Kumar, Emma Restall Orr, David Korten and Neil Douglas-Klotz.

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### Titles in Our Low-Cost Book Series

*What is Green Spirituality?* Edited by Marian Van Eyk McCain.

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In this pamphlet, the author looks at a number of ideas in the hope they may contribute to our understanding of how things come to be in the physical world.

Starting with key points of development in the field of General Systems Theory, Michael moves on to encourage us to develop our understanding through observation, as opposed to taking things apart to see what they are made of.

Essentially, this pamphlet puts forward a holistic approach for studying the way things are and come into being and invites us to consider a number of fascinating areas of discovery.

**Michael Colebrook** was for many years the production editor of the GreenSpirit Journal. A scientist all his life, his working career was devoted to research on the planktonic ecosystem of the North Atlantic Ocean and the North Sea.

