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Archetypes: The Strange Attractors of the Psyche

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You don't see something until you have the right
metaphor to let you perceive it.
Robert Stetson Shaw

Consider the statement: 'Healthy systems don't want homeostasis. They want chaos,' which appeared recently in *Science* (Pool **18**, p. 604). While echoing a major point of controversy between Jung and Freud, it advances a theory based on three premises. First, flexibility depends on choices. Second, chaos offers more choices than order. Finally, to the degree that adaptation requires flexibility, chaos becomes essential for growth. In short, where stability is a product of adaptation, chaos's contribution rivals that of order. Deceptively simple, these three premises are revolutionising the way researchers look at phenomena.

Understanding chaotic - or complex - dynamics is greatly facilitated by visualising them. Imagine, for example, what it would be like to watch a ten kilometre race in a stadium enshrouded by fog. Realising that it is impossible to view the race from an overall perspective, you decide to stand near the start and finish line, expecting to view the contestants at the start, the finish, and as they emerge from the fog on each lap. Two contestants, known to be virtually evenly matched, shake off their nervousness as they anticipate dogging one another's heels throughout the race. And then the start. All seems normal, but by the end of the first lap events have taken a decidedly bizarre turn. Each time the pack makes its way past your vantage point, some marathoners are inexplicably absent. At other times the absent ones reappear, but others formerly present are missing. Most incredibly, some contestants emerge from the fog running in the opposite direction. Even the two evenly-matched contestants, who began the race side by side, are by now nowhere near one another.

If this is confusing for the observer, consider the poor runners. The two evenly-matched marathoners who began the race side-byside, for example, begin to notice that the lanes are set up to allow one to remain on the shorter, inside path to the finish. In fact, all of the runners are prevented from leaving their lanes and moving to the inside track. Consequently, the ones on the inside lanes quickly outdistance the others. But that is not all that is bizarre about this race. What the spectator cannot see, owing to the fog, is that the paths themselves meander off periodically in strange and convoluted configurations. This explains the apparently haphazard behaviour of the contestants, for they are trapped on paths that keep them running in all directions. What began as an orderly event has deteriorated into chaos.

As a young schoolboy, I was fascinated by science and mathematics. In college, however, certain disparities between data and model were attributed to the inability of the former to live up to the latter. In effect, reality was seen to exist in a fallen state. I discovered the same assumptions later on in psychology, where similar conflicts between theory and practice were likewise explained. For example, patients whose perceptions and behaviour failed to conform to given theories and models were labelled 'schizy', 'borderline', 'resistant', or perhaps closest to the truth, 'atypical'. Furthermore, a profound level of discomfort with such deviations from the ideal seemed to be reflected in many clinicians' responses to such patients. Pressure to conform, medication, institutionalisation, and surgery comprised a virtual index to the level of that discomfort.

In the early days of my clinical training my colleagues and I periodically defused the frustration of trying to bring order out of chaos by saying of our patients 'Well, what do you expect? After all, they're crazy!' Not entirely flippant, our comments reflected an early suspicion that disorder was' not entirely maladaptive. So it was that when we encountered Jung's assertion that chaotic dynamics are present in all psychological development, normal and abnormal, we were hooked. Particularly appealing was the way in which he combined scientific rigour (accounting for chaotic processes through discovering their meaning) with an openness to traditions of inquiry generally excluded from academic circles. Moreover, interwoven with his theories was an orientation toward data and a style of explanation that simply rang true. Never did I imagine, as I embarked on my training in analytical psychology, that after twenty-odd years the hard sciences and Jungian analysis would 'find a convergence in what has become one of the most fascinating and exciting fields of inquiry in science today. Known simply as 'chaos theory', this research seeks to describe complex dynamical systems previously beyond the scope of classical

mathematics and physics. Not surprisingly, such research into the behaviour of non-linear systems is radically transforming many operant paradigms of the worldwide scientific community today. And most interestingly, it offers ways of understanding chaos not only from the traditional Jungian perspective - that of meaning - but from a psychodynamic one as well.

Chaos Theory[1]

Chaotic systems stretch and fold back on themselves in self-reinforcing loops, like the feedback in a microphone-speaker system (**GOLD-berger 6**, pp. 604-6). For example. as sound enters the microphone and is amplified, the speakers broadcast it into space, whereupon it enters the microphone again, is amplified, and sent out through the speakers in a loop that builds upon itself. When the volume reaches an ear-splitting screech, someone jumps up to turn down the amplifier. This is a simple geometric progression wherein not only the volume, but the rate of increase of the volume, quickly accelerates to infinity. Feedback loops can be defined by equations that 'work on themselves', so to speak, so that the result of any one computation becomes the basis for computation of the next.

Iteration[2]

Such equations are defined as 'iterative'. Unlike linear equations, which proceed in an orderly fashion to a predictable outcome, iterative equations determine their own destiny. Their outcome is rarely predictable, for where they have been often seems to have little effect on where they continue to go. In fact, iterative equations are so unpredictable that any two of them that begin with only slightly differing values wind up, like our two marathoners, in vastly different places. This particular phenomenon - one of the defining characteristics of chaotic dynamics - is called 'sensitive dependence on initial conditions', or SDIC for short.

Sensitive Dependence on Initial Conditions[3]

Perhaps the most widely referenced example of SDIC is that of Edward Lorenz, who in 1960 was using computers in an attempt to simulate weather patterns. The remarkable thing about his programs was their unpredictability: like actual weather, the patterns would

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[1] See explanations at end of paper for this and following headings.

change slowly in apparently random ways. Randomness, as anyone who studies statistics quickly realises, is extraordinarily difficult to generate. One day, however, Lorenz tried to replicate an earlier 'run' of the program. He punched in the numbers where it had left off, and went to get a cup of coffee. When he returned, the new run had so diverged from the old that it bore virtually no resemblance. As James Gleick recounts in his book *Chaos*:

> *This new run should have exactly duplicated the old. Lorenz had copied the numbers into the machine himself. The program had not changed. Yet, as he stared at the new print-out, Lorenz saw his weather diverging so rapidly from the last run that, within just a few months, all resemblance had disappeared. He looked at one set of numbers, then back at the other. He might as well have chosen two random weathers out of a hat. His first thought was that another vacuum tube had gone bad (**Gleick 4**, p. 16).*

In fact, a tube had not gone bad. What had happened was this: the computer computed its results to six decimal places, but reported them on the print-out only to three. When Lorenz fed the print-out starting point back into the computer, the differences in the decimal places (differing only by ten-thousandths!) compounded geometrically as the program iterated. Thus, a minuscule difference in the starting point led to totally different results: SDIC.

With regard to weather patterns, SDIC has become known as the 'butterfly effect' (**Pool 19**, pp. 1290-3). A particularly dramatic way of portraying SDIC, it maintains that the weather in, say, Chicago can be altered by as minor an influence as a butterfly fluttering its wings in Beijing the week before. Thus, SDIC 'imposes fundamental limits on predictability…. Science will never know certain things' (*Ibid.*, p. 1290). On the other hand, while minute changes can produce enormous differences over time, the underlying equations that determine their results are often quite simple. Thankfully so, for the second major characteristic of chaotic dynamics (the first being SDIC) is that they are aperiodic, meaning that they fail to demonstrate those periodic recapitulations of themselves generally associated with stability and order. Thus, even though chaotic dynamics never settle down into fixed configurations from which predictions could be made, at least their underlying dynamics can be described by relatively simple equations.

I first became aware of the mathematical simplicity of chaos when as a young boy I would sneak into the office of my father's factory and play with the calculators. Unlike the simple punch-in-the-number-pull-the-crank adding machines of that time, these were analogue computers that could perform amazingly complicated computations involving twelve digits. They were, of course, the precursors of today's digital computers. One day, as I was applying some newlyobtained

grade school mathematics knowledge to the task of blowing up the calculator, I punched in '1' and divided it by 'O'. To my delight, the calculator lost itself in the computation and spun endlessly from digit to digit in all twelve places as it searched determinedly for somewhere to settle. My father, hearing the noise and perhaps smelling the smoke, walked in, pushed the cancel button, and informed me that such computations could break the machine. He was not completely put out, I suspect, for we shared an appetite for many of the same diversions.

Mutual Inhibition Equations4

Fundamental to all scientific enterprise is the generation of simple mathematical constructs to describe complex situations. For example, the amateur scientist mentioned above quickly realised that one simple equation could account for an infinitely complicated behaviour of his father's calculating machines. There are, of course, many others. Of particular interest are those that describe the behaviour of oscillators. Rather than elaborating complex dynamics that simply amplify themselves, these equations summarise the dynamics of two or more competing influences. Mutual inhibition equations, for example, describe interactions between factors that moderate one another, as for example a population and its food supply. Sometimes referred to as 'predator-prey,' or 'host-parasite' models, they are actually complicated feedback loops that can be written mathematically as '$x_{1+1} = rx_1 (1-x_1)$'. If 'x_1' refers to the size of the population and 'r' designates its rate of growth, then '$1-x_1$' accounts for factors that moderate growth. With regard to the food supply, for example, as the population (x_1) increases, the food supply ($1-x_1$) decreases. For simplicity's sake, 'l' refers to the maximum number and 'o' the minimum. Now suppose 'x_1' refers to a group of chickens and '$1-x_1$' to its food supply. When a population of 65 chickens eats into its food supply of 100 pieces of corn, 35 are left. Clearly, if the food supply cannot regenerate itself fast enough, the population of chickens will have to decline. There may come a time in the future, however, when it declines so much that the food supply can support the diminished number of chickens. Then the population could again begin to grow. Much, of course, depends on the rate of growth or decline of the population ('r' in the equation above).

At first glance, such equations seem to mandate that the higher the growth rate (r), the larger the population. Thus, iteration - computing $rx_1(1-x_1)$, substituting the result back into the equation to produce the next result, and so on - ultimately leads to steady-states wherein

population and food supply reach an equilibrium.1 Curiously, however, when the growth rate enters the 3's (3.1, 3.2, 3.3, and so on), the final populations suddenly split, whereupon the population oscillates between two values. These splits are called 'bifurcations', and if the growth rate continues to rise, the populations cycle among four, and then eight, sixteen, thirty-two and more values. Thus, as the growth rate rises through the threes, these bifurcations themselves bifurcate, leading to an expansion in bifurcations ad infinitum. Called 'period doubling', the end product is so chaotic as to be practically unrepresentable. Yet most surprisingly, for a large number of such equations this chaotic period doubling occurs so reliably that its appearance can actually be predicted, generally when $r = 3.569946$.

Viewed geometrically, graphing the equation at this point reveals a line that splits into two curves, resembling a parabola lying on its side with its apex at the point where the bifurcation occurs. As bifurcations increasingly bifurcate, the graph becomes so confused that virtually nothing is differentiable. However - and this is perhaps one of the most curious phenomena in chaotic dynamics - as the rate 'r' continues to increase, there appear repetitions of the original pattern of bifurcations within the chaotic state. In other words, patterns of order emerge from the chaos.

The analysis of oscillators, particularly those that lead to bifurcations and period-doubling, suggests comparisons between the languages of chaos theory and analytical psychology. Just as the language of geometry assists in understanding the language of algebra, the language of analytical psychology assists in understanding the language of the unconscious, which reflects the self-regulation of the psyche via tensions of opposites. Curiously, when chaotic dynamics are expressed in the language of geometry, the results are simply spectacular. The images produced portray complex patterns of movement captured in time and space. Called 'strange attractors', these images indicate where the movement of the functions will end up, in configurations that attract the development of the mathematical functions that define them. Not only do pictorial representations of strange attractors rival the most intricate and beautiful of symbols, but, in portraying dynamic systems, they also resemble mandalas.

Attractors5

The term 'attractor' is used in mathematics and physics to specify the pattern into which a particular motion will settle. For example, a pendulum that is subject to friction will eventually stop swinging. The point directly underneath the pendulum when it stops is called

a single-point attractor, as it appears to attract the motion of the pendulum during each successive swing, bringing it to a state of rest over that point. A pendulum that is not subject to friction swings back and forth in a repetitive fashion, constantly tracing out the same pattern of motion. This is called a limit-cycle attractor. There are other kinds of attractors (those that trace a torus, for example) that settle down into constantly repeating patterns. Thus, graphs of limit cycle attractors consistently recapitulate themselves as they retrace their paths (circle, ellipse, torus, etc).

Complex - or chaotic - dynamics, however, never retrace the same path twice, even though they do achieve patterns that are recognisable. While these patterns share a generic similarity with simple attractors, their obvious peculiarities - primarily that they never repeat themselves in predictable ways - lead them to be called strange attractors. Unlike regular attractors, which settle into repetitive cycles of limited size, strange attractors contain 'isolated orbits … [that display] no orbital stability … the future behaviour [of which] has a sensitive dependence on initial conditions' (**Tomita 23**, p. 218)

Thus, a strange attractor is the epitome of contradiction, never repeating, yet always resembling, itself: infinitely recognisable, never predictable. Graphing them is a fascinating enterprise wherein one 'must be equipped with a protective coating of physical intuition' (**Dewdney 2**, p. 108), for unlike the three steady-state attractors mentioned above, their orbits are so complex as hardly to make sense. When Edward Lorenz mapped the attractor that underlay his 'weather machine', for example, it turned out, as in **Figure 1**, very complex, essentially unpredictable, but displaying an obvious order.

Repetitive bifurcations generate stretching and folding dynamics, the strange attractors which display a 'self-similarity' within their patterns. Such patterns 'are invariant under a transformation which replaces a small part by a bigger part, that is, under a change of scale' (**Sander 21**, p. 789). These patterns are also 'scale-invariant', in that the components seem 'to "know" about each other over distances far in excess of the range of the forces between them' (*Ibid.*, p. 789). Interactions between scale and dimension - self-similarity and scale-invariance - can be seen in coastlines, mountains, clouds, ferns, trees, rivers, frost patterns on a window, and so on.

In 1975 Benoit B. Mandelbrot invented the term 'fractal' for these patterns that resemble themselves no matter how much they are magnified (**Mandelbrot 12**, p. 10). One way to envision fractal dimensions is to imagine measuring the length of a coastline. To begin this exercise, look at the coast of a country or state on a map. Notice the many indentations and protuberances that signify bays and peninsulas, and using a scale of inches to miles, measure the length

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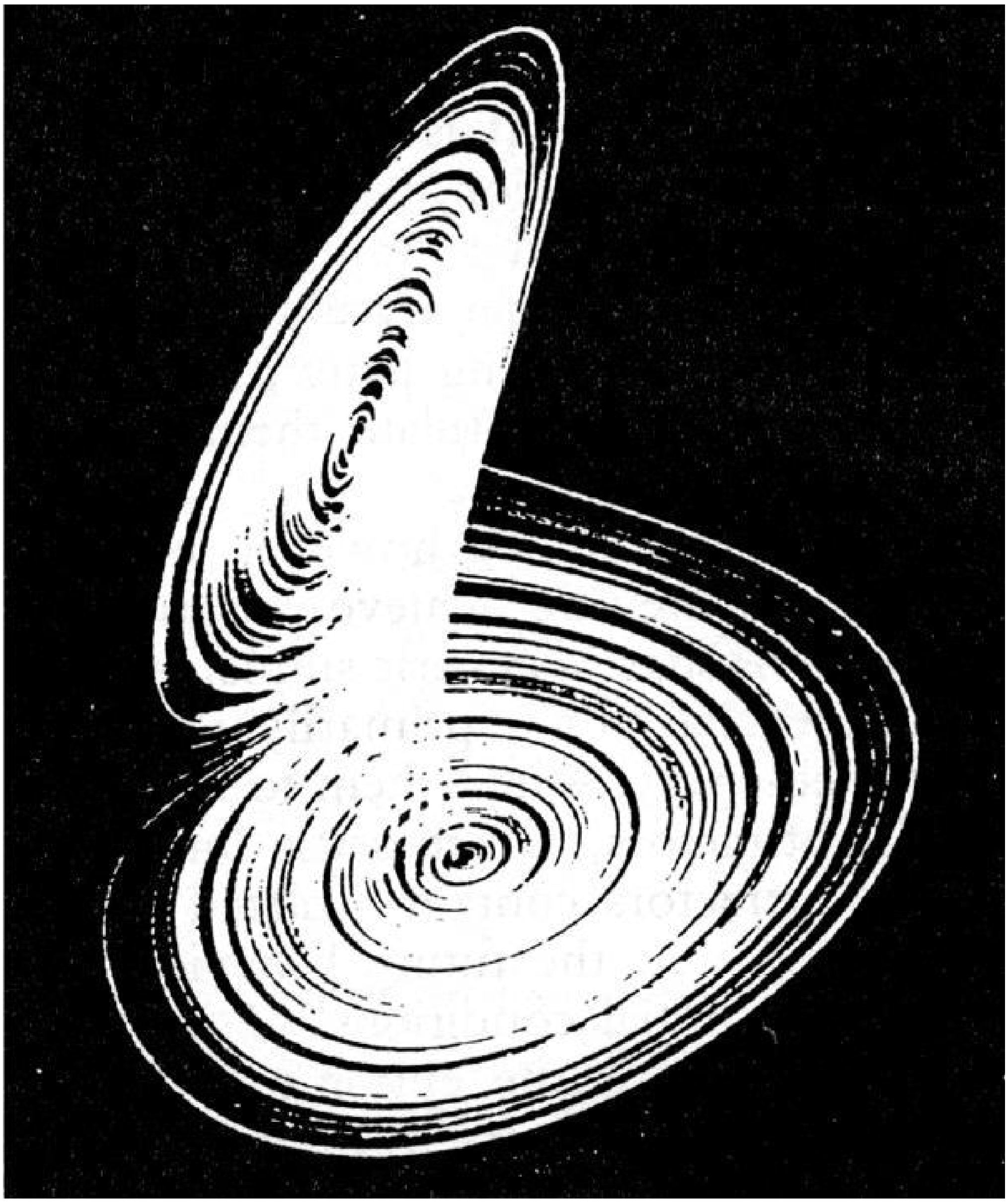
Figure 1



of the coastline. Next, obtain a map with a larger view of the same coastline, and using that map's scale of inches to miles, measure the coastline again. Two things become apparent immediately. Firstly, while the second map will show more detail than the first, the new details bear an uncanny resemblance to the old. That is, the peninsulas and bays on the first map now appear on the second to be themselves comprised of smaller-scale peninsulas and bays. Secondly, when the coastline as measured on the second map is converted to miles, it turns out to be longer than the first measurement. So now imagine that, wishing to obtain a really accurate measure of the length of the coastline, one goes to the coast itself and measures it with a one metre rule. Every peninsula and bay that appeared on the maps is now seen to be made up of smaller peninsulas and bays. Furthermore, much of the coastline cannot be measured at all because the onemetre rule is unable to bend around every small indentation and protuberance. Furthermore, using smaller measuring devices encounters even smaller peninsulas and bays, until the scale reaches the size of the actual molecules that make up the by now infinitesimally small grains of sand that in turn make up the pebbles that make up the little peninsulas and bays that make up the larger peninsulas and bays, and so on. Thus, the smaller the measuring scale, the more accurate

the measure - and the longer the coastline! And for every smaller scale, there is an even smaller entity to be measured. Thus, peninsulas and bays are fractals. Varying the scale simply reveals further elaborations of self-similarity and scale-invariance.

Chaos and Jung[6]

As mentioned above, both Jung's metapsychology and chaos theory utilise the language of imagery to describe similar phenomena. Selfsimilarity and scale-invariance could be applied to much of Jung's topography of the psyche, while bifurcation and period-doubling can be found in his energetics. For example, at the heart of Jung's metapsychology lie his experiences with the word-association experiment. His contribution to the study of this instrument was to notice the lapses in attention that occurred periodically with regard to certain words. That is, every now and then a subject would pause before giving a response to a stimulus word. Until Jung noticed them, these pauses had simply not been factored into the results of the experiment. By keeping track of such pauses - or ‘lacunae’ - and exploring in detail the images associated with their occurrence, Jung was able to construct a network of associations around the pauses. He called these networks ‘complexes’, and hypothesised that whenever one's attention became entwined in an association of the complex, energy would be drawn toward the complex and away from consciousness.

Fractal attractors demonstrate a similar phenomenon. (Benoit Mandelbrot, who has done perhaps the most extensive research on fractal attractors, feels that *all* strange attractors are fractal (**Mandelbrot 12**, p. 197).) Like the marathoners in the example at the beginning of this essay, orbits periodically disappear from the graphs of attractors only to reappear again in different places later. And like the graph of the mutual inhibition equation cited above, the patterns emerge from and recede into chaos as areas of fractal attractors are magnified. In effect, periodicity alternates with aperiodicity. To the extent that complexes derive continuity from their feeling-tones (self-similarity), and to the extent that all levels of associations participate in those feeling tones (scale-invariance), it is tempting to equate complexes with fractal attractors. More accurately, however, complexes correspond with the dynamics that are represented by fractal attractors. Fractal attractors themselves are not the dynamics that inform them, but images of those dynamics. At this level of comparison, then, fractal attractors resemble symbols.

Comparing fractal attractors with symbols suggests a very interesting elaboration on chaos theory. For example, describing the phenomenology

of mandalas, Jung said: ‘All that can be ascertained at present about the symbolism of the mandala is that it portrays an autonomous psychic fact, characterised by a phenomenology that is always repeating itself and is everywhere the same. It seems to be a sort of atomic nucleus about whose innermost structure and ultimate meaning we know nothing’ (**Humbert 8**, p. 240). In essence, Jung is ascribing self-similarity and scale invariance to the mandala. That its innermost structure and ultimate meaning are basically hidden certainly place it in the category of a fractal attractor. Conversely, fractal attractors might be seen as a special kind of symbol. In this manner, chaos theory suggests parallels with that which Jung described as the content, or topography, of the psyche. With regard to his energetics, chaos theory seems even more pertinent.

While Jung's theories contain rich and accurate analyses of the images that reflect unconscious processes, adequate attention has rarely been focused on the psychodynamics of the processes. In effect, image *is* meaning *is* explanation. How it happens is clearly secondary to what it means. Consider Neumann, for example: ‘The emergence of a group of archetypes split off from the basic archetype, and the corresponding group of symbols is the expression of spontaneous processes in which the activity of the unconscious continues unimpaired’ (**Neumann 14**, p. 324). The words ‘spontaneous processes’ are generally about as far as analytical psychology goes toward explaining the underlying mechanics of the process. Chaos theory, however, may offer some interesting elaborations.

Combining Jung's language with that of chaos theory leads to an interesting description of the process of individuation: when the tension between consciousness and the unconscious reaches a certain critical value (like the constant mentioned above), chaos enters the psychic realm (bifurcations and period doubling). This leads to a psychic situation that consciousness finds virtually impossible to differentiate. Yet, if the chaos is allowed to continue (the tension of opposites maintained), recognisable patterns (symbols/fractal attractors) eventually appear. These patterns represent the emergence of order from chaos and, if correctly interpreted, give insight into the status of the process.

Oscillators Revisited7

Jung's metapsychology is grounded in the idea that tensions of opposites generate psychic energy and regulate psychological growth. Tensions of opposites, moreover, are essentially oscillators. With that in mind, let us return for a moment to the language of mutual

inhibition equations and integrate it with Jung's metapsychology. If chaos ensues at the point at which bifurcations multiply geometrically, the same might be true of that stage of individuation sometimes referred to as the dark night of the soul. Neumann states that '… the manifestations of the unconscious vary with the intensity and scope of the conscious mind' (**NEUMANN 14**, P. 324). In other words, the more consciousness dominates the psyche, the more the unconscious becomes empowered. This is Jung's fundamental law of compensation. Expressed in the language of chaos theory, increasing the intensity of consciousness (Neumann, above) increases the value of the inhibiting element in the equation (1-x). Confining this process to the analytic container, however, is analogous to increasing the 'r' value of the mutual inhibition dynamic that exists between consciousness and the unconscious. The resulting feedback loop intensifies the interactions between ego and unconscious, in effect 'pushing' the system. When the psychological counterpart of the Feigenbaum constant is reached - that is, when the tension between consciousness and the unconscious reaches a certain intensity - chaos ensues. And just as surely as pushing the system will generate chaos, maintaining the pressure ensures that the chaos will generate patterns that recapitulate the original tension that started the whole thing off. These patterns are analogous to uniting symbols in Jung's theory.

The descent into the unconscious is an essential ingredient in Jung's model of psychological development. Described with reference to such terms as the night sea journey, the nigredo, the *prima materia,* the great mother, and so on, it has been a central theme for elaboration. (See especially, **HARDING 7**, pp. 317ff, **NEUMANN 14**, pp. 32 off, and **HUMBERT 8**, pp. 121ff.) Such elaborations generally conform to Jung's central premise that the ego must sacrifice itself in order to maintain its capacity for growth. Humbert, for example, explains the process thus: 'Each time that the world, or an image of the world, is constituted, the individual tends to become enveloped in a dynamic of inclusion, that is, the archetype of the Great Mother' (**HUMBERT 8**, p. 121). When 'the momentum of life … demand[s] that these confinements be torn apart at one time or another', one must resist the desire to impose a conscious order on the ensuing chaos (Ibid., p. 121). Rather, 'the ego must renounce all attempts to appropriate unconscious dynamics. The reason for this renunciation is that sacrifice brings about a change in the orientation of libido. It allows libido to regress into the unconscious and thereby makes it possible for new forms of emerge, (Ibid., p. 122). Again, like the mutual inhibition equation cited above, the process begins with a tension of opposites, develops into chaos, and completes itself when a new order appears.

Of particular interest is the analogy between raising the 'r' value in mutual inhibition equations and the containing of the process of individuation in a vessel. Jung seemed to understand that the use of rituals and rites to create a vessel wherein chaos could occur reflected humankind's implicit understanding of the need to raise the 'r' value of the tensions of opposites. Expressed in today's scientific language, 'chaos often appears in an otherwise well-behaved physical system when it is "pushed" - when a certain parameter of the system is increased so high that irregular motion sets in' (**Pool 17**, p. 27). From the alembic to initiation rites, the chaos that is generated by containing tensions - in the case of initiation rites, for example, that between childhood and adulthood - is contained and exploited for growth. When such containers are absent, 'r' values fail to reach their critical point, chaos is frustrated, and neurosis ensues.

The idea that chaotic dynamics are essential to healthy growth is rapidly becoming the focus of many researchers in the biological sciences, who are gathering data on interesting reversals of the standard models of healthy rhythms in the human body. Standard models generally assume that

> *… a healthy body has rather simple rhythms. In this view, the different parts of the body either tend to homeostasis, where interrelated systems reach an equilibrium, or else they have some simple periodic behaviour, such as the rhythmic beating of the heart. A disorder will have a more complicated, less controlled tempo' (Ibid., p. 604).*

Research into EKG and EEG patterns suggests, however, that chaotic patterns provide 'a healthy variability that allows the organ to respond quickly to a variety of stimuli' (Ibid., p. 606). Systems lose their capacity to respond to new situations when they are limited to regular patterns that are incapable of chaotic phases. Dynamic systems require a diversity of responses to survive the unexpected. Thus, '… a healthy physiological system has a certain amount of innate variability, and a loss of this variability - a transition to a less complicated, more ordered state - signals an impaired system' (Pool **18**, p. 604). In other words, chaos provides a complexity of response that order cannot.

While the idea that chaos is healthy is in itself revolutionary, even more significant is the discovery that such chaotic unpredictability occurs not because of randomness or noise, but is programmed into the organism from the beginning. Jung's metapsychology, deliberately heuristic and synthetic, attempted to encompass the rich diversity of chaotic dynamics. His interpretations of symbols, for example, consider them in all of their manifestations, rather than reduce interpretations to single meanings. Grounded in observation and open to revision (heuristic), his theories seek comprehensive explanations that respect all the diverse dimensions of phenomena (synthetic), rather than focus on single explanations (reductive). He understood that, like fractal attractors, there does not exist, at *any* level of reduction, a linear interface between the unconscious and consciousness.[2]

As in the case of fractal attractors, Jung's metapsychology finds the action at the boundaries. He constantly reiterated the value both of staying on the boundaries - submitting oneself to tensions of opposites - and of learning the means to tolerate that tension. Beginning when one is ‘gripped’ by an unconscious content (the ‘living idea’ (**Jung 9**, pars. 746ff.)), the process of transformation demands that one endure tensions of opposites until symbols appear that can establish new patterns of integration. A typical human failing, Jung felt, was the inclination to seek a haven in one or another fantasy of order. Even then, however, while transformation is disrupted, it is not cancelled.

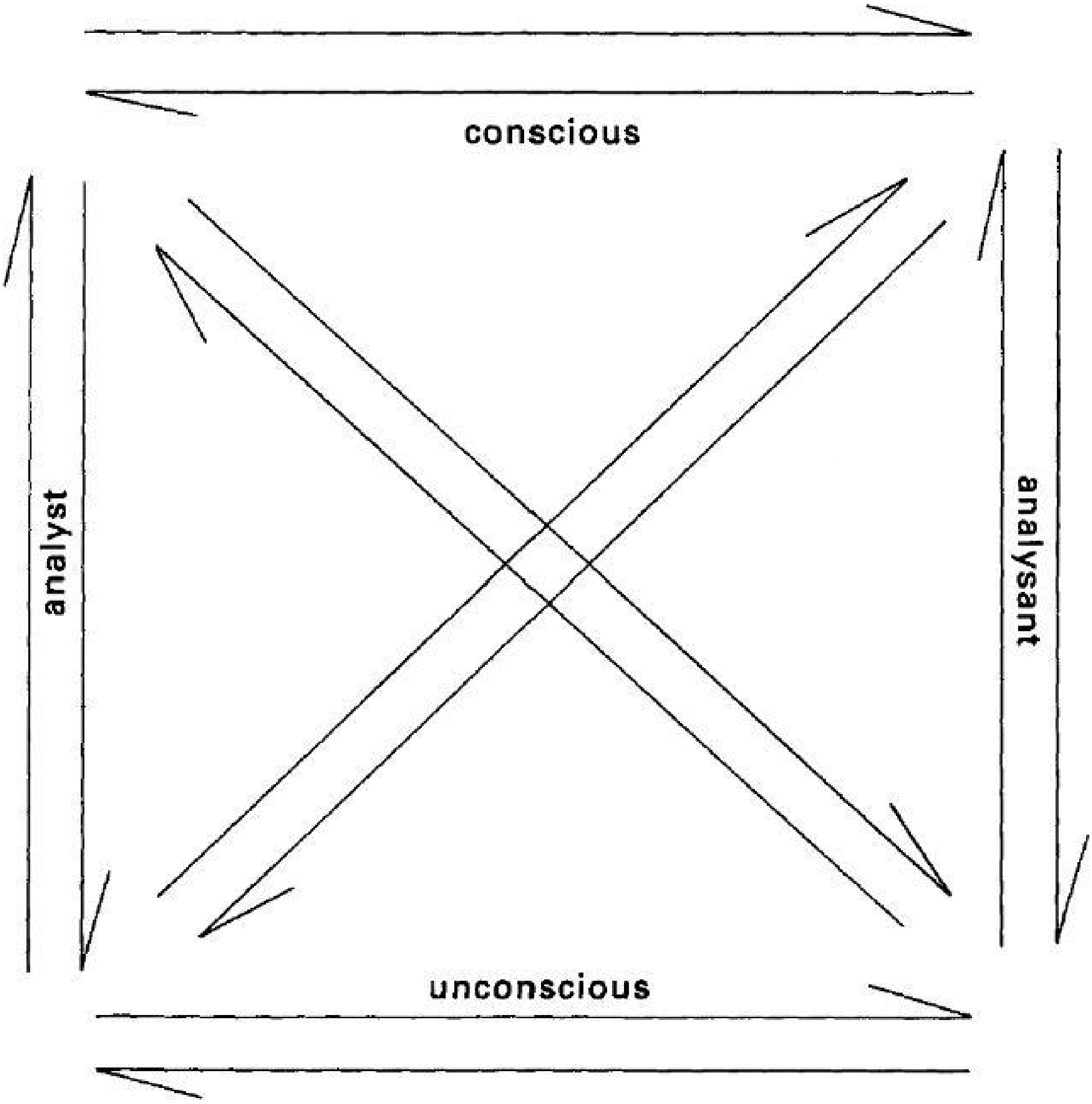
Most analytical psychologists can attest to the fact that the chaos that appears in the life of the psyche is generally not very well-received by contemporary psychology, which uses terms like ‘dissociation’ and ‘decompensation’ to describe it. Every analyst has experienced patients who suffer emotional breakdown when either their own system, or the one in which they dwell, is ‘pushed’: by unemployment; relational problems; reactions to toxic situations, both psychological and physical; ageing, and so on. Subsequent breakdowns are habitually treated with hospitalisation, where restraints and medication seek to enforce homeostasis on the chaotic organism. Often, however, such interventions only aggravate the situation, leading to an endlessly chaotic loop of suppression and regression.

Jung did not underestimate the danger inherent in such situations. He did not agree, however, that all incursions of systems into chaotic dynamics necessarily warranted the measures taken to resist them. Thus, analytical psychologists traditionally utilise in their clinical practice images and techniques remarkably consistent with chaos theory. A most fruitful parallel between chaos theory and analytical psychology concerns the manner in which analysis proceeds as a result of the encounter between analyst and patient, a matter of central importance to Jung. Analysis of the complex dynamics that underlie the surface of the analytic encounter permeate his essays on alchemy, for example.

Transference and Countertransference

One of the first and most enduringly interesting essays to elaborate on Jung's work was written by C. A. Meier, in which he describes ‘the two persons of analysand and analyst’ as ‘two systems’ that are ‘polarised’ into ‘the conscious and the unconscious psyche’ (**Meier 13**, p. 280). His well-known diagram of the dynamics that characterise the analytic relationship describes a twelve-fold system

Figure 2



He feels that 'the constellating influences and everything we can talk about: the difference, the interaction, the polarity, the tension of opposites and all these famous compensatory constellations, etc., in short, all the dynamics playing between the two systems are all to be regarded as being contained in this pattern' (**Meier 13**, p. 281). Interestingly, while he felt that in the case of the unconscious-unconscious dynamic between analyst and analysand 'epistemological difficulties

reach their culmination', nevertheless 'they are far from being merely theoretically posited'. In fact, he says, in this realm 'we are moving in the matrix of synchronicity' (Ibid., p. 281).

Analysts can clarify their perceptions of what is taking place in the process, says Meier, by raising the level of their own consciousness. To accomplish this, he recommends employing the four functions: 'the most basic, the most elementary, the most neatly defined concepts in Jungian psychology' (Ibid., pp. 282-3). While this will never guarantee a 'Laplacean' predictability, nevertheless 'in view of the fact that the two systems [analyst-analysand] have constantly to be understood as interfering, we must assume that whatever the analyst's system looks like to begin with, he [*sic*] should always be able to change altogether every single moment of the process, so as to produce a tension of opposites with regard to the system of the analys-and, so that something really can happen and things can really be constellated and problems can really come to a head; and for that purpose, of course, the analyst has to be capable of really rotating and revolutionising his [*sic*] own system time and time again' (**Meier 13**, pp. 282-3). In speaking of 'rotating and revolutionising his own system', Meier is referring to the four functions. And certainly there can be little doubt that he is describing something at the heart of the analyst's pursuit of consciousness.

Especially intriguing in the light of the chaos theory, however, are the phrases 'two systems … interfering' and 'to change altogether every single moment of the process', for it is upon ideas identical to these that the process of identifying attractors, strange or fractal, is based. 'Two systems interfering' locates the dynamics of oscillators firmly within the analytic context, and 'To change altogether every single moment of the process' underlines the importance of manipulating the 'r' value of such an oscillating system. And finally, Meier's view of analysis as a twelve-fold dynamic reveals the nearly infinite potentials for the growth arising from the 'multi-oscillatory' dynamics of the analytic process. In fact, what Meier suggested be done in psychology back in 1968 is exactly what is being done in the hard sciences today.

Perhaps the one genre of symbol that portrays most adequately the dynamics of individuation is the mandala. Meier says that '… it should never be forgotten that almost all Eastern mandalas, in their graphic representations, make it very clear that they are ever vividly rotating, thus indicating the dynamics, the process, the character of the ever repeated night-sea-journey during the "dark night of the soul"' (**Meier 13**, p. 287). The *dynamism* that characterises individuals, says Meier, permeates the analytic process. The analyst who is unaware of his own 'rotation' (of the four functions, in Meier's

schema) can hardly comprehend the complex dynamics of the analytic process. And while chaos theory promises to extend analysis beyond fourfold or twelvefold schemata, analysts who do not understand their own role in the oscillatory dynamics of analysis - unaware of their fractal dimensions, uncomfortable dwelling on the irreducible boundaries, or insensitive to the effects of sensitive dependence on initial conditions - lack the information necessary to locate both themselves and their patients in the analytic process.

Summary and Conclusions

Fractal attractors suggest that chaos theory shares with Jung's theory some common methodological presuppositions. For example, that fractal attractors permeate nature and natural processes correlates with Jung's premise that there are patterns inherent in the psyche at birth. Furthermore, that chaotic dynamics are currently being evaluated for their ability to regulate organic processes promises exciting discoveries that may illuminate Jung's psychology of self-regulation. Finally, chaos research offers analytical psychology the opportunity both to extend its dialogue with the hard sciences and to refine thereby their understanding of Jung's metapsychology.

Such a dialogue might begin with Jung's emphasis on tensions of opposites and their importance for the regulation and development of the psyche, which is entirely consistent with the discovery that boundaries between basins of attraction in fractal attractors can never be reduced. Furthermore, chaotic dynamics do not lend themselves to the kind of reductionism that La Place - and in his footsteps Freud - hoped would lead to the ability to predict the outcome of dynamical systems. Finally, if chaotic dynamics permeate nature to a degree far beyond that previously thought to be true, it may mean that the hard sciences are now beginning to grasp how the mind apprehends both itself and the world around it. In other words, chaos theory may be providing insight primarily into the mechanisms of the mind itself. Thus, once again fractal attractors and archetypes may not be simply analogous to one another. They may be synonymous.

C. A. Meier's plea for a more scientific approach in Jungian psychology' now finds itself, twenty years later, able to utilise some very sophisticated theory and the computer hardware and software to back it up. That it happens to coincide beautifully with Jung's metapsychology may be either fortuitous or inevitable. Whichever it is, three important implications of chaos research should be noted by every analytical psychologist. Firstly, the dominance of reductionism in the politics of ideas is being challenged: 'The trend in science, and

in physics in particular, has been toward reductionism, a constant breaking things down into little bitty pieces…. What people are finally realising is that that process has a dead end to it. Scientists are much more interested in the idea that the whole can be greater than the sum of its parts' (**Gleick 5**, p. 134). Secondly, the teleological view that organic processes seek homeostasis is under revision:

> *It was once common wisdom that biochemical reactions inevitably converged rapidly to a thermodynamic steady state and that this steady state was unique. Similarly, at the systemic level, a restrictive view of the concept of homeostasis dominated physiological thinking, and it was suppposed that physiological control functioned exclusively to restore transiently disturbed systems to a steady state. It is now recognised that this is not the case. Complex dynamical behaviour is an aspect of biological regulation' (**Rapp 20**, p. 179).*

And finally, symbolic appreciation of previously insoluble dynamics is increasing. With regard to epidemiology, for example:

> *Until recently, researchers restricted themselves to simple solutions of their models, assuming the complicated ones both were too difficult to deal with and had no applications to the real world. The work on chaos has lifted a psychological barrier, showing that even complicated behaviour of epidemiological patterns may yield to analysis by uncomplicated mathematical models (**Pool 17**, p. 28).*

Jung devoted his life to freeing psychology from the inadequacies of order, while developing the means to find patterns in chaos. How exciting it is to find mainstream science now doing the same!

So what happens to our poor marathoners, who from the beginning of this article have been running their bizarre race on a strange attractor? Well, perhaps they have learned an important lesson. Perhaps life ought not to be a race. Rather, life's goals may often need to be secondary to life's processes. If so, one may sometimes have to subjugate one's goals to the importance of where one happens to find oneself at the moment. In Jung's language, teleology must sometimes give way to finality.

That both analytical psychology and science employ virtually identical metaphors to understand particular phenomena guarantees neither the accuracy of those metaphors nor that they describe the same phenomena. The evidence is growing, however, that chaos theory and analytical psychology *are* describing the same dynamics. And the fantasy of order - that spurious product of reductionism - is slowly giving way to the realisation that chaos is far healthier than previously imagined. Perhaps the Haitian Spirit 'Gede' says it best: 'What is insanity? Insanity is doing the same thing over and over again and expecting something different to happen' **(Blue Rider 1)**.

Appendix

1Chaos Theory

That chaotic systems stretch and fold back on themselves defeats any attempt to predict their outcome. Nevertheless, their lack of predictability is not stochastic (random). In fact, their non-stochastic unpredictability, which lends them much of their unique fascination, also leads science to use the term 'chaos' in a manner that differs from the vernacular. Thus,

> *chaos is a mathematical concept that is somewhat difficult to define precisely, but it is probably best described as 'deterministic randomness'. A chaotic system is deterministic - it obeys certain equations that can seem quite simple - but behaviour of the system is so complicated that it looks random. It is impossible to predict the long-term behaviour of a chaotic system because any uncertainty in the initial conditions of the system increases exponentially with time. Chaos is order disguised as disorder, a sheep in wolf's clothing (**Pool 17**, pp. 25-28).*

While the quest to discover order in disorder has occupied science for centuries, chaos theory renders that quest decidedly more ambiguous. On the one hand, the effects of stretching and folding undermine the La Placean notion that determining the origin assures the prediction of outcome. On the other hand, however, 'since much of the complicated, seemingly random behaviour in the world may actually be simple in origin, it may be much easier to analyse this complexity than was previously thought' (*Ibid.,* p. 26).

2Teration

Chaotic systems are perhaps best - and certainly most enjoyably - analysed through the use of models. Because chaotic systems stretch and fold, they are basically feedback loops that build upon themselves, a process that can be understood mathematically and represented on a graph. Graphs of chaotic systems bear little resemblance to the familiar graphs of linear equations, however. Graphing the equation y=ax+b, for example, which is the equation of a line that intersects the y axis at b, is relatively straightforward: simply substitute numbers for the x values to discover the corresponding y values, and plot the resulting points (a series of (x, y) values) on a graph. This kind of equation is known as a linear equation, in that values are matched: for every x value, there is a corresponding y value.

The equation $y \rightarrow ay^2+c$, on the other hand, means that 'the next value of y to be computed is the product of a (constant) rate of

increase and the square of the value of y currently being computed, combined with the value of the constant c.' This is a non-linear iterative equation, in which values are computed and then substituted back into the original equation to be computed again.

3Sensitive Dependence on Initial Conditions

Non-linear iterative equations lack the predictability associated with linear equations. In the equation $y \rightarrow ay^2+c$, for example, suppose that y is set at 2, a at 1, and *c* at o. Squaring y yields 4, which becomes the new y value, to be squared to compute the next y value (16), which is then squared to compute the next *y* value (256) and so on. With each computation the equation is said to iterate, and in only five iterations the value of y becomes 4,294,967,296. However, suppose y is set at 2.001 (for simplicity, remember, a is set at 1 and c at 0). After five iterations (rounding off each iteration to three decimal places for simplicity) the value is 4,364,168,157.546. So, an initial value that is larger by only 1/1000 yields a result that is larger by 69,200,861.546 after only five iterations! With regard to any system, this 'sensitive dependence on initial conditions', means that '… tiny changes in certain features could lead to remarkable changes in overall behaviour' (**Gleick 4**, p. 178).

Thus, not only do values that are substituted in the equation increase, but the rate at which they increase itself increases (accelerates). If, as in the above example, y>1, the equation rapidly approaches infinity. If y is 1/2, for example, y^2=14, whereupon the new value of y, or 1/4, is substituted into the equation to yield 1/16, and so on. Again, after five iterations, the value of y is 1/4,294,967,296. Thus, if y<1, the equation rapidly approaches zero. Finally, if y=1, the equation, no matter how many times it is iterated, always equals 1. Consequently, there are only three destinies for the iterations of such equations: approaching infinity or zero, or stuck at one.

4Mutual Inhibition Equations

Mutual inhibition equations are a subcategory of finite difference equations, whose general formula is '$x_{i+1} = S(x_i)$'. This is simply mathematical language for 'the next value of x to be substituted in the equation is the result of the current substitution of x in the equation.' Thus, if S(x) is determined to be (x+1), adding one to any starting value of x - written mathematically as 'x_i' - leads to the next value of x - written as 'x_{i+1}.' If x_i is 1, then x_{i+1} is 2, which is

resubstituted into the equation to yield 3, which is resubstituted to yield 4, and so on as far as is necessary. Each time, the computed value of x is substituted in the equation to yield the next value of x, which is then substituted in the equation to yield the next value of x, ad infinitum.

With regard to the mutual inhibition equation cited in the text, when values for 'r' are fixed between 0 and 4, and as values for x are substituted in the equation, the graph of the function that results resembles a smoothly increasing curve. As 'r' reaches 3.569946, however, the graph suddenly behaves in a very bizarre manner. In 1974, the physicist Mitchell Feigenbaum calculated a constant (4.669201609) that could be used with mutual inhibition equations to predict when period doubling would become chaotic. It suddenly splits into two branches that resemble a horizontal parabola whose arms diverge from one another. These branches subsequently split, each into two, to form four branches of two horizontal parabolas. The process of bifurcating continues until branches are intersecting other branches and the resulting combination of bifurcations and intersections is simply a mass of jumbled up lines. This is chaos. (See **Gleick 4**, pp. 59-80, and especially p. 63n, for an excellent description of this process.)

5Attractors

The equation $y \rightarrow ay^2+c$ cited above demonstrates the relationship between dynamical systems and limits. If $y>1$, the limit is infinity and, correspondingly, if $y<1$, the limit is zero. Thus, as each equation iterates, infinity and zero are said to attract the equation's results. In the case of $y=1$, the iterations lead nowhere. Consequently, attractors are seen to be the determining factors in the equations, of which classical physics has generally recognised three types. The chief characteristic of all three attractors is that the motions that lead to them can all be expressed as linear equations. Consequently, every position on the attractor can be determined by substituting values for the variables in the equation. Linear equations lead to predictability, which accounts for their great popularity in scientific theory.

Strange attractors, however, are a bit more complex. For example, 'a strange attractor can be considered as the limit set of an unstable manifold which is a curve of infinite length with an infinite number of loops without self-intersection and with a Cantor set as a cross-section' (**Lauwerier 11**, p. 59). This very intimidating phrase means simply that a strange attractor is an area of unpredictability inhabited by an infinitely long curve that goes on forever in loops that never

intersect. 'Unstable manifold' refers to a strange attractor's ability to connect many points in a manner that is unpredictable. Moreover, that such a series of loops has a 'Cantor set as a cross-section' refers to a fascinating configuration discovered by Georg Cantor. Cantor sets are formed by removing from a line segment its middle third, doing the same for each remaining segment, and continuing that process ad infinitum. 'The set generated in this way has the remarkable property of containing uncountably many points -' i.e. the same -i.e. for any points as the whole real line - yet being nowhere dense -i.e. for any point in the set one can always find a point not in the set arbitrarily close to it' (**Gibson 3**, pp. 19-20).

Paradoxically, creating more and more points within the same space generates less and less density. Cross-sections of strange attractors resemble Cantor sets because they consist of some regions from which orbits disappear and others wherein they reappear. Technically, '… the orbit leaves the plotting area but returns after a few iteration steps. We may imagine that the orbit is leaving along a branch of the unstable manifold and returning along a branch of the stable manifold' (**Lauwerier 11**, p. 83). This process is identical to the disappearance of an orbit along the unstable manifold of a strange attractor.

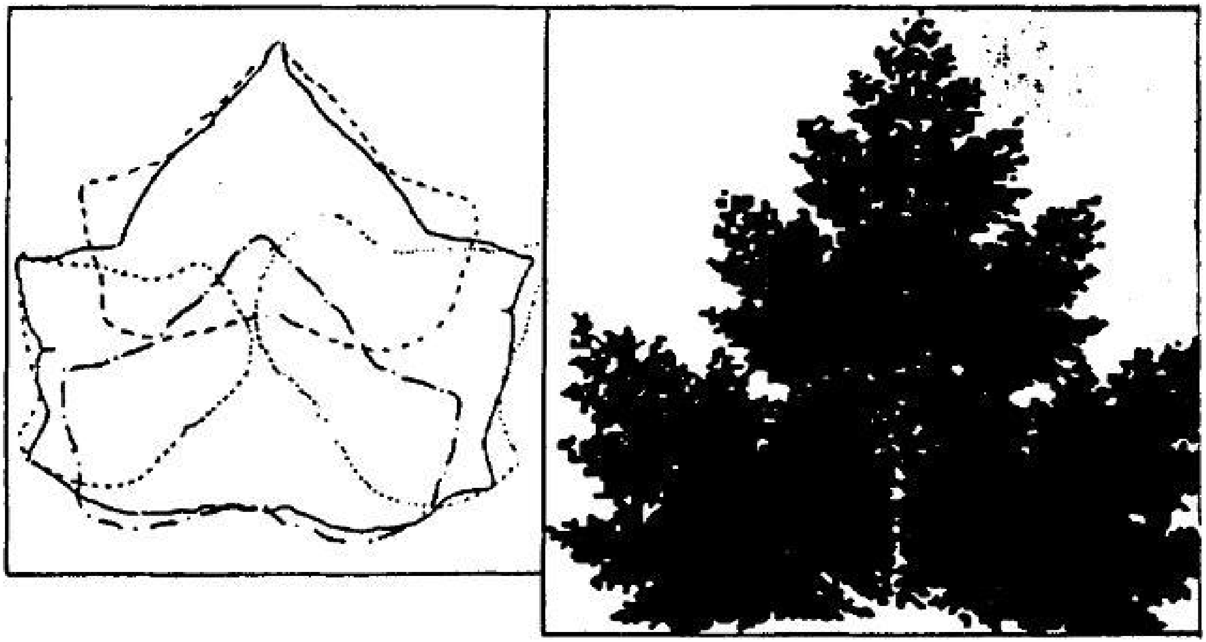
Because iterative equations constantly repeat the same dynamics, every point on their graphs is connected with all other points on the graph. Thus, the three-dimensional map of a strange attractor becomes particularly intriguing when a 'phrase portrait for the full system [is constructed] from time-series data for a single product … by slicing the orbit with a plane transverse to the flow' (**Schaffer 22**, p. 407). For example, suppose that the graph of the Lorenz attractor (see illustration) is reduced to the set of points that crosses the plane of the x and y axes (essentially a Poincaré section), effectively creating a cross-section of the attractor. Every point on that cross-section denotes an orbit that leads to every other point on the attractor. Such a portrait of an attractor that is 'frozen' in one of its phases - the 'phase portrait [constructed] from time-series data for a single product' - is a dynamic entity that contains all the information necessary to recapitulate the entire configuration of the attractor ('for the full system'). By mapping such points and assigning different colours to the rapidity with which they 'emerge' or 'recede' from the plane, extremely intricate patterns are created that resemble fantasma-gorical works of art (see especially **Peitgen 15**).

6Chaos and Jung

If a complex is a fractal attractor, what is the archetype? Without being too technical, archetypes correspond with unstable saddle points, homoclinic orbits and bifurcations. These enable orbits to leave the origin, wander around the attractor in an indeterminate manner, and return. In short, archetypes break up the linear flow of consciousness, infusing it with a chaotic/non-linear flow. When computers are used to generate geometric images of fractals, several fascinating things occur. Firstly, boundaries of the images can never be reduced to simple lines. Rather, focusing on smaller and smaller sections of the boundaries reveals greater and greater complexity. Secondly, at varying stages during the magnification process, they recapitulate the original conflict between competing solution sets. Thus, even though chaos permeates boundary areas, self-similarity and scale invariance generate an order within that chaos.

Fractals are useful for discerning the components of images. With regard to computer generated images, for example, mathematical processes called 'affine transformations' are being used to find configurations that can be shifted around to construct familiar images. In fact, 'affine transformations can be applied to any object - triangles, leaves, mountains, ferns, chimneys, clouds - or even the space in which an object sits. In the case of a leaf, the idea is to find smaller, distorted copies of the leaf that, when fitted together and piled up so that they partially overlap, form a "collage," which approximately adds up to the original, full leaf' (**Peterson 16**, p. 284). With affine transformations, part and whole emerge. Like genetic coding, they allow entire images to be constructed from only one or a few basic shapes.

Figure 3



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As affine transformations are plotted on a screen, an image appears that is the attractor for all the transformations. Such an attractor is, of course, a fractal attractor, for it is comprised of configurations that, however much they are magnified, retain their self-similarity at all scales.

With regard to chaos theory, symbolic images are like the phase portraits (Poincaré sections) mentioned above. While each captures a portion of the attractor in great detail, none is sufficient to represent all its dynamics. Thus, for the most comprehensive understanding of the attractor, one must combine as many phase portraits (symbolic images) as possible. The beauty of fractal geometry is that it provides visual evidence of such processes.

7Oscillators Revisited

The boundaries between oscillating solution sets of finite difference equations can never be reduced to simple lines, but always contain a healthy dose of chaos, wherein lie recapitulations of the oscillations themselves. Yet while constructing phase portraits of attractors involves systems of complex dynamics interacting with planar surfaces, the interface between analyst and patient is even more complex. For one thing, like the boundaries separating basins of attraction within fractal attractors, the boundary between analyst and patient never settles down and can never be reduced to a simple image. For another, the dynamics established through the interaction between analyst and patient are fractal, that is, they are self-similar and scale invariant. This leads to multiple interweavings that, like computer-generated pictures of fractal attractors, stagger the mind.

Thus arises a dilemma similar to that which Anthony Stevens poses with regard to the shadow: dealing with it without being possessed by it. Consequently, any analyst who attempts to dwell in only one of the solution sets will invariably 'oscillate' into the other. To resist the boundaries is to lose the adaptability of chaotic dynamics, thereby courting enantiodromia through empowering other basins of attraction. As if one were sucked into the unstable manifold of an attractor, one becomes torn in many directions by the power of the unconscious forces at work. Like the alchemical process involving the separation of spirit from body, of Mercurius from matter, one must suffer the tension of opposites until a symbol appears that offers a means of bringing about the necessary coniunctio that establishes a new integration of soul and body.

Only by becoming strong enough to dwell on the boundary, where chaos and recapitulation of conflict preside, can the analyst keep the

opposing forces at a manageable level. This is, of course, the classic Jungian method: by dwelling within tensions of opposites, not only is the patient spared the usually disastrous enantiodromia, but the transcendent function can suggest new creativity out of old chaos as well.

Were Jung's model of the psyche to be compared with fractal attractors, its dynamics might resemble unstable manifolds along which orbits disappear from the phase portrait and stable manifolds along which they return. The transcendent function, and the uniting symbols produced thereby, would be like stable manifolds by which unconscious dynamics could be integrated into consciousness. By dwelling within tensions of opposites, the ego activates the stable manifolds through 'an attitude of judgment … The avowed purpose [of which] … is to integrate the statements of the unconscious, to assimilate their compensatory content, and thereby produce a whole meaning …' (**Jung 10**, par. 754ff). Maintaining such a tension can be accomplished only when the ego understands that 'the characteristic flexibility in response of living organisms to external excitation will never be fully understood without invoking chaos as a fundamental mode of motion' (**Tomita 23**, p. 235). Thus, in order to best optimise its capacity for adaptation and growth, the ego must recognise that chaotic dynamics are essential for living systems to have the options necessary to maintain equilibrium.

References

1 The blue rider theatre company (8 July 1989). After Mountains, More Mountains. Chicago.
2 Dewdney, A. K., (1987). 'Computer recreations: probing the strange attractor of chaos'. *Scientific American*.
3 Gibson, C., Ed. (1988). The Facts on File Dictionary of Mathematics. New York. Charles Letts.
4 Gleick, J. (1987). Chaos: Making a New Science. New York. Viking Press.
5 Gleick, J. 'New images of chaos that are stirring a scientific revolution'. *The Smithsonian*.
6 Goldberger, A. in Pool, R. (1989). 'Is it healthy to be chaotic?' *Science*, 243.
7 Harding E. (1973). Psychic Energy: Its Source and its Transformation. Princeton. Princeton University Press.
8 Humbert E. (1988). C. G. Jung: The Fundamentals of Theory and Practice. Wilmette, Illinois. Chiron Publications.
9 Jung, C. G. (1933). 'The real and the surreal' Coll. wks, 8.
10 Jung, C. G. (1955). (Mysterium coniunctionis) Coll. wks, 14.

11 Lauwerier, H. A. (1986). 'Two dimensional iterative maps', in Holden, A. V., ed. Chaos. Princeton. Princeton University Press.
12 Mandelbrot, B. B. (1983). The Geometry of Nature. New York. W. H. Freeman.
13 Meier, C. A. (1971). 'Psychological types and individuation', in Wheelwright, J. B., ed. The Analytic Process: Aims, Analysis, Training. New York. G. P. Putnam's Sons.
14 Neumann E. (1973). The Origins and History of Consciousness. Princeton. Princeton University Press.
15 Peitgen, H.-O., Richter, P. H. (1986). The Beauty of Fractals: Images of Complex Dynamical Systems. New York. Springer Verlag.
16 Peterson, I. (1987). 'Packing it in: fractals play an important role in image compression'. *Science News*, 131, 18.
17 Pool, R. (1989). 'Is it chaos, or is it just noise?' *Science*, 243.
18 Pool, R. (1989). 'Is it healthy to be chaotic?' *Science*, 243.
19 Pool, R. (1989). 'Is something strange about the weather?' *Science*, 243.
20 Rapp, P. E. (1986). 'Oscillations and chaos in cellular metabolism and physiological systems', in Holden, A. V., ed. Chaos. Princeton. Princeton University Press.
21 Sander, L. M. (1986). 'Fractal growth processes'. *Nature*, 322.
22 Schaffer, W. M., Kot, M. (1985). 'Nearly one-dimensional dynamics in an epidemic'. *Journal of Theoretical Biology*, 112.
23 Tomita, K., (1986). 'Periodically forced non-linear oscillators', in Holden, A. V., ed. Chaos. Princeton. Princeton University Press.

This paper will be followed by another in the next issue of this Journal by J. R. Van Eenwyk on the application of chaos theory to 'The analysis of defences'.

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