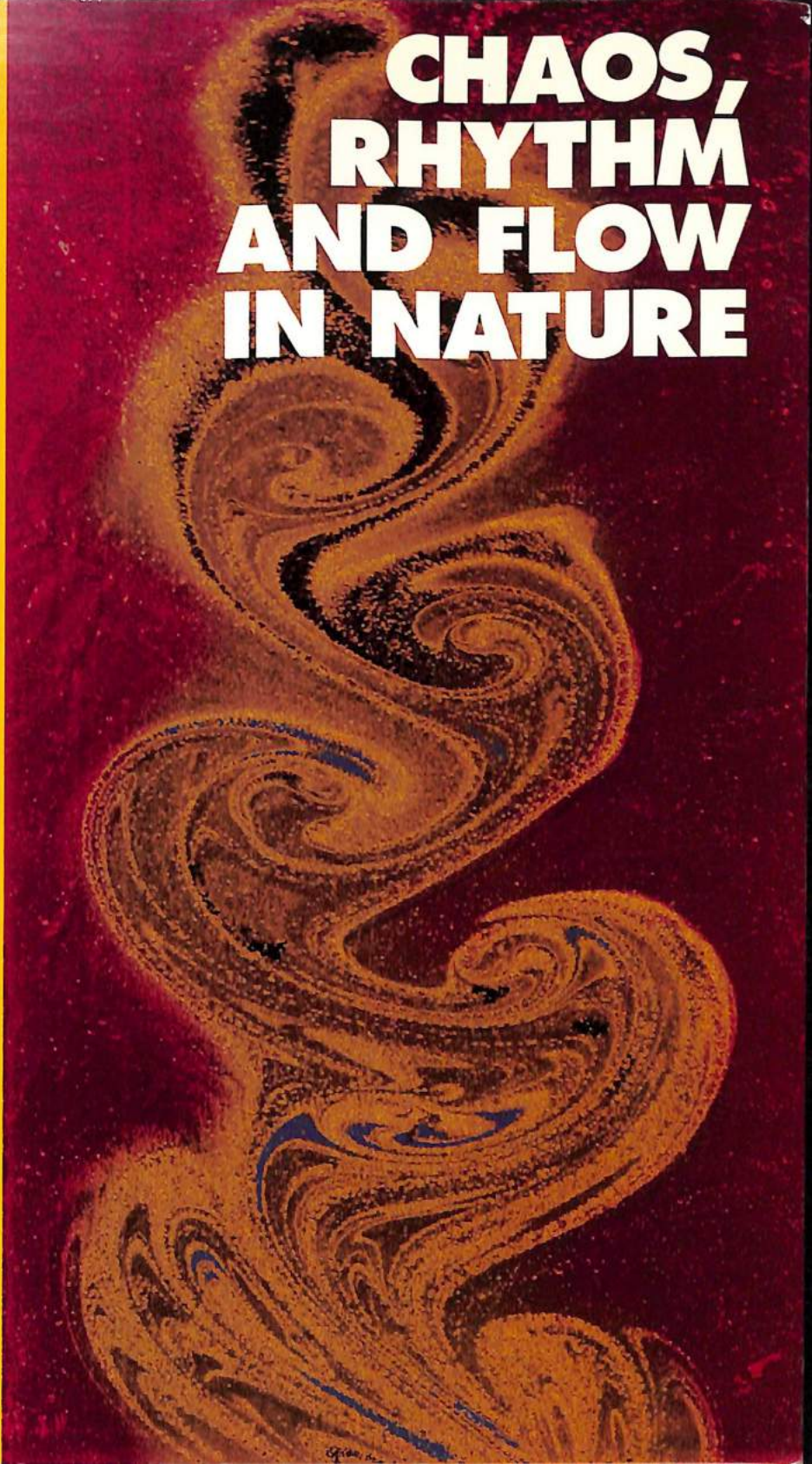


CHAOS, RHYTHM AND FLOW IN NATURE

THE GOLDEN BLADE 46



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The Golden Blade 1994

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The Golden Blade No.46

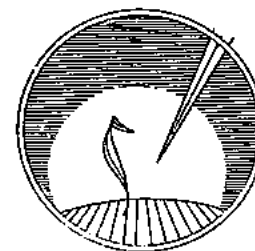
Edited by William Forward
and Andrew Wolpert

Floris Books

First published in English in 1993 by Floris Books.

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Anthroposophy springs from the work and teaching of Rudolf Steiner (1861-1925). He describes it as a 'path of knowledge, to guide the spiritual in the human being to the spiritual in the universe.'

The aim of this annual is to bring the outlook of anthroposophy to bear on questions and activities of evident relevance to the present, in a way which may have a lasting value. It was founded in 1949 by Charles Davy and Arnold Freeman, who were its first editors.

The title derives from an old Persian legend, according to which King Djemjdid received from his god, Ahura Mazdao, a golden blade with which to fulfil his mission on earth. It carried the heavenly forces of light into the darkness of earthly substance, thus allowing its transformation. The legend points to the possibility that humanity, through wise and compassionate work with the earth, can one day regain on a new level what was lost when the Age of Gold was supplanted by those of Silver, Bronze and Iron. Technology could serve this aim; instead of endangering our planet's life, it could help to make the earth a new sun.

British Library CIP Data available

ISBN 0-86315-173-6

ISSN 0967-6708

Printed in Great Britain
by BPCC Wheatons Ltd, Exeter

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Editorial notes

Goethe was very conscious of his unique contribution to natural science, as is apparent from his conversations with his secretary, Eckermann: 'That in my century I am the only person who knows the truth in the difficult science of colours — of that, I say, I am not a little proud.' He was perhaps all the more conscious of this since this was much less widely recognized than his contribution to literature. Specifically, his ability to relate nature observations to the full context of human experience and to pay just as careful attention to the observer as to the observed in the investigative process — that is, to work from what we might now term a holistic worldview — gave rise to results which now seem much more worthy of attention than they may have done to the scientists of his day.

As the people of our time become increasingly disposed to see the Earth itself as a living organism and beyond that to see it as a living organism within a living universe, more credence is being given to the Goethean approach to an understanding of nature.

Goethe developed a process of observation which, by withholding the judgments and conclusions at which we so easily arrive, allows the observer to become a vessel in which the creative ideas behind the phenomena may apprehend themselves. This presupposes firstly, that there is a spiritual foundation to the world; that is, that there is a realm in which such creative ideas live, and secondly, that human beings may gain conscious access to it.

The whole tendency of scientific and religious thought in

the last centuries has been for the spirit to become less and less important. This has led to the point where the meaning or spiritual intentions at work within the universe are regarded as a subject for speculation rather than experience.

Little wonder then, that there are so many signs of demoralization and decadence in our civilization, Where could a new vigour, a new sense of the wholeness, indeed meaningfulness of the world come from?

Just as the initiate leaders of the ancient Greeks had to undergo a process of self-transformation through trials and rigorous testing in order to apprehend the intentions of their gods, so perhaps it must become the task of all of us today who seek the answer to this question, to freely take on the discipline required to enable us to become the vessels in the sense described above.

This issue of the *Golden Blade* is devoted to the work of scientist who have striven to apply the scientific principles developed by Goethe in their research. May the reader find inspiration as well as information.

W.F.

A.W.

The Universe as Organism in Space and Time

Lawrence Edwards

In September 1992 a group of anthroposophical scientists gathered in Hawkwood College in Gloucestershire to share their experiences, and to debate possible fields for further exploration. As one of their number I have been asked to contribute this article describing some of the things I said there, and I am adding some further things which have arisen since then. An account of this sort is bound to rely heavily on previously published material, and only a very short résumé can be given here. A detailed account of these things is included in my book *The Vortex of Life* (Floris Books 1993), and readers must be referred to that if they find the following account to be terse and inadequate.

It was many years ago that Rudolf Steiner suggested to us that in the thought-forms of projective geometry it would be possible to find elucidation of many of the problems of the growth and development of living organisms, and years of study since then have shown this to be a most fruitful field of research. At the very heart of our geometry we find the process of Collineation. This transformation is linear and is as elementary and fundamental as can be found anywhere. Yet we have simply to apply it iteratively, that is, applying the transformation over and over again, to have our page covered with a complicated and very beautiful field of form,

and many of the forms thus arising bear strong resemblance to the forms we see in living nature.

Nearly thirty years ago, when I first started to apply these things practically I realized that mere resemblance was not enough; one would have to test the forms of nature, over and over again, with the utmost rigour and mathematical precision before one could be ready to make the definite statement that out there, in the great plant garment of the earth, this kind of geometric form was really manifesting itself. And when, after many years of work, this result was achieved, I found that the work had put into our hands a powerful tool by means of which subtle variations in the plant forms could be measured and recorded, which could otherwise not have been observed. In a short article such as this, only one aspect of such subtle variations can be dealt with.

Certain specially important cases arise when one ensures that the invariant elements of one's transformation coincide with the absolutes of Euclidian space. Prominent amongst these is a whole series of egg-like forms, covered by the possibility of infinite families of spiralling curves, and these we have to recognize as perhaps the most fundamental and archetypal forms which our geometry is able to produce. And once one's eye is opened to this kind of form one finds it occurring with remarkable frequency in the world around — in actual bird eggs (250 species have been studied and analysed), in pine cones and various types of seed head, in sea shells and other maritime creatures, in various microscopic organisms, in the human body in the ventricles of the heart, in the pineal gland and, in a somewhat modified form, in the uterus, and paramountly in the vast array of leaf- and flower-buds pervading the plant kingdom. It is with these latter that we are specially concerned.

The geometry of buds

When we study these buds we find ourselves particularly concerned with a parameter, λ (lambda) — a number which arises when we have made our calculations and which encodes for us vital information about the form we are dealing with. Lambda does not tell us, in the normal sense of the word, the shape of the bud, but much subtler qualities of its form. When λ is near to unity our form is rounded and relaxed, giving us an outgoing and expansive feel; it is neither very pointed at one end nor very blunt at the other. But as λ increases the form becomes increasingly sharp at one end and correspondingly blunt at the other; the sides at the bases tend to stiffen towards straightness; one gets the feeling of contraction and tension (see Figure 1.1).

It is now just over ten years since I started finding the λ s of the buds on a daily basis, ensuring strict comparability over a long period of time, from day to day and from week to week. I could never have guessed the strange — and from the point of view of our modern consciousness unlikely — realms of existence into which this investigation was going to lead. From the start it became clear that this sphere of the flower and leaf buds is one which is subject to constant change and variation, that these changes are slight and subtle, that they are cyclic in quality and display definite correlations with the inter-relationships of Moon and planets. After ten years of concentrated work on this one has to realize that one still stands only on the threshold; it would be quite impossible to include even those details which already have been discovered in an article of this sort; the reader must be referred to *The Vortex of Life* and the considerable *Supplement and Sequel* to this which is already published.

Much of the work already done has been with respect to

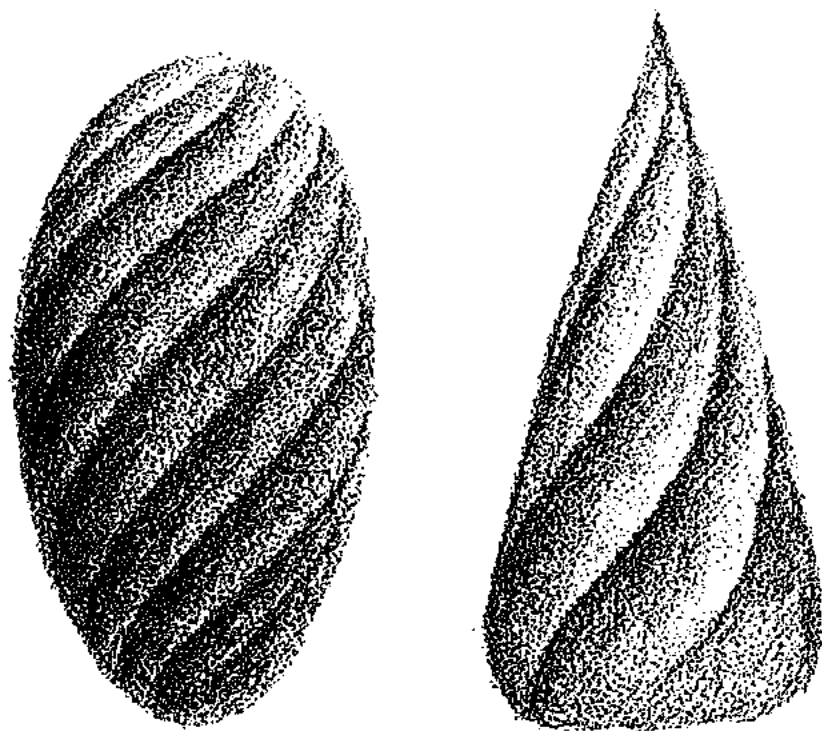


Figure 1.1. When our parameter, lambda (λ), is near unity, our geometric forms are rounded and relaxed as seen on the left. As λ increases the form become increasingly pointed, blunt and straight-edged, showing every sign of an inward tension. This parameter shows itself as a very sensitive way of assessing the degree of tension shown in any such form.

the leaf buds of our great deciduous trees. These present to us a remarkable phenomenon. Next season's buds appear on their branch in the late summer and by the end of September they seem to be almost completely formed; and thereafter they hang on their branch apparently passive and dormant for something like six months, until in the following Spring they come to their great apotheosis when they open to the light and air of the great world around them. And this

opening, this gesture of relaxation, of, as it were, the giving of themselves to the great world, is signalled for us, in our mathematics, in a dramatic fall in the λ of the form, a fall right down into the negative numbers when the enclosed and enclosing egg-like form of the bud transforms into the open chalice-like form of the spreading leaves.

A link with the planets

Figure 1.2 is a graph of the λ of the buds on a Beech tree measured between December 1989 and March 1990; it is typical of hundreds of such observations that have been

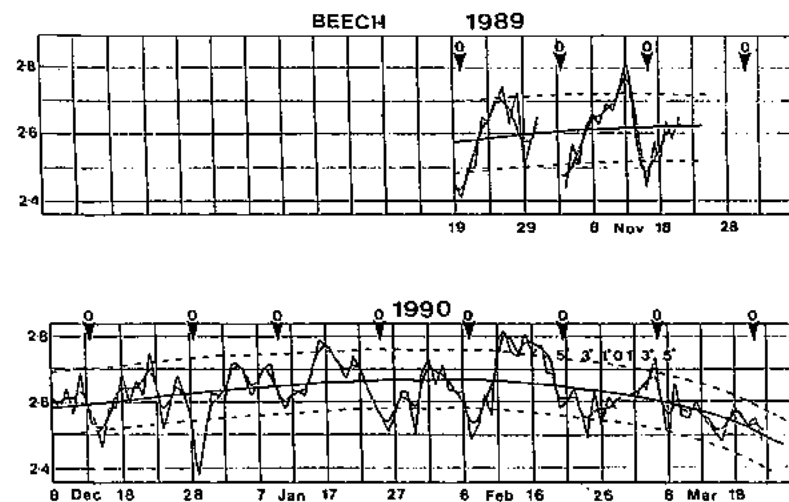


Figure 1.2. This shows the λ -values of the leaf buds of a beech tree during the winter of 1989-90. The downward-pointing arrows show the moments when Moon and Saturn were in alignment with the Earth. It will be noticed that the graph shows a temporary fall on every such occasion except the last two, March 7 and 20. On these dates Mars was also in alignment with Saturn and it has been, over many years, a well-attested fact that the close presence of Mars has a strongly inhibiting effect on the phenomenon.

made on this and other species during the last ten years. We see a rhythmic fall in λ roughly every fourteen days, and this is a constant feature found in many different species. But further investigation proved that the matter is more complicated than this. The periodicity for the Beech, averaged over a long period of time, turned out to be about 13.6 days, while that for the Oak was found to be slightly over 14 days, and that of the Birch was found to be as much as 14.7 days. The strange complexity of this matter can to some extent be cleared up when one realizes that these are in fact astronomical rhythms. It has been found over many years that the dips in the curve for the Beech are timed by the moments when Moon and Saturn move into straight line with the Earth — a phenomenon which we call an alignment. When the bodies concerned are Moon and Mars it is the Oaks which respond and when it is Moon and Venus, it is the Birch. Somewhat similar phenomena have been found to hold for a number of species of flower buds during the summer months. Here it is the Primroses which have been found to respond to lunar alignments with the Sun, the Buttercups with Jupiter and the Geraniums with Mars. (see Figure 1.3).

The greater organism

At this point it would be well to consider two essential properties which we must see as belonging to any truly living organism. The first is the remarkable inter-relationship and the inter-dependence of all its parts. The quality of the whole overshadows the separate parts so overwhelmingly that it knits them together into one single organism. No single part can move, or act, without all the others being affected; no single part can suffer any injury without all the others suffer-

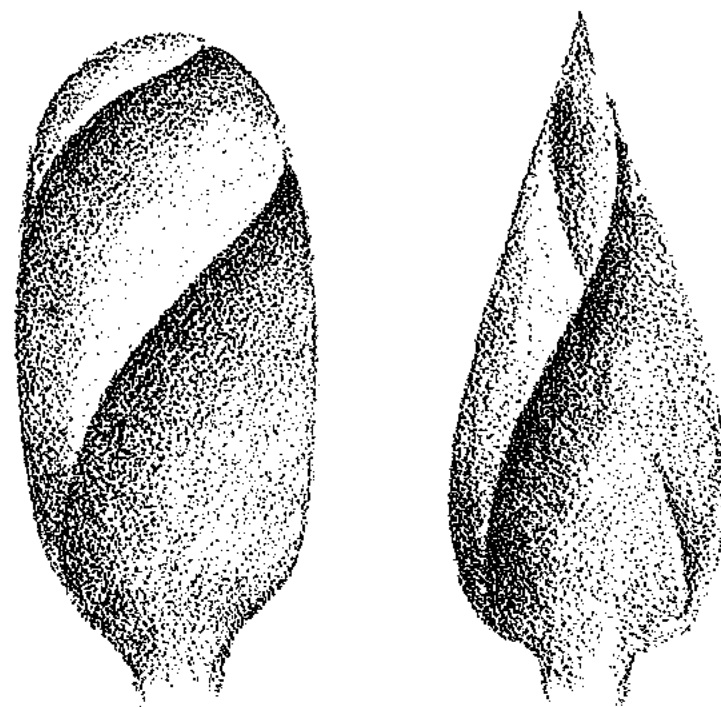


Figure 1.3. On the left, the bud of a wild cherry. With $\lambda = 0.9$ we have the sweetness of spring preparing to unfold. On the right, with $\lambda = 7$, we see the bud of the wild rose, growing almost in the form of a thorn.

During the winter the buds of our great deciduous trees tend to take a very tiny step in the general direction from the right-hand form to the left-hand and back again, every fourteen days in a complicated correlation with astronomical rhythms.

ing, in some way, also. This why we call the musical instruments in our churches, an *organ*. A large one will consist of ten thousand separate pipes, but when the organist plays (if he is a real organist!) it will sound like a single instrument. The second is that the virtue of the whole is so over-riding that something of its quality is stamped indelibly on to each of its parts. We see this again and again when studying living organisms. Each separate part, each in its own special way, becomes an image of the whole. The microcosm mirrors the

macrocosm which needed it, fashioned it and gave birth to it. Pick a branch from a tree, and see how the separate twigs on it branch off to left and right, just as the branches themselves ray out from the main trunk; you have in your hand a whole tree in miniature. In more subtle ways a similar case holds for the human body; over and over again, in head and limb we see the various parts displaying the three-fold nature of the whole organism.

The things we have been describing here bear upon our whole perception and concept of the world around us, in which we live. Did we believe that we live in a dual world, the solar system wheeling mechanically through space whilst the plants sprout in isolation from us under our feet? But now, not so. We begin to see this world around us as a mighty living organism, in which the movement and activity of planet and plant are deeply integrated one with another in the most complex ways. The inter-relationships of the heavens come to meet us again in the great plant garment of the earth on which we walk. No star can move, but a plant responds.

Yet we must go further than this. In our search for the whole reality of the plant we must respect its integrity in time as well as in space. The plant we see today is different from the one we had before us yesterday, and different again from the one we will have tomorrow; yet it is still the same plant. We must learn to see the plant as a whole being, existing in time. These millions of little buds, hanging on their branch all through the long winter months, what are they doing? They are waiting, waiting for the wonderful moment of their culmination, when in the Spring they will open themselves to the light and air of the universe around them. But during those long dark months it is not just waiting. Every fourteen days they experience a little Spring, a little Easter. Their λ drops slightly, they make a little gesture towards opening, towards relaxation, a little smile shall we say, but then — the

time is not yet ripe, not yet — and they close tight shut again until the next two weeks shall have elapsed. In this moment, are they experiencing in advance just a foretaste of the bliss which lies ahead of them, or is it the tree remembering that of the previous Spring? Who can tell? But what we do know is that this whole winter's activity bears the mark of a living organism, an Organism in Time. Each little part of it mirrors the character of the whole, and the whole is knit into a frame, every part of which proclaims the nature of the essential being.

The streams of time

From the start it must be clear to us that thought of this kind do not come easily to the modern mind. The world is not going to believe the things written above, readily — and quite rightly so. In a sphere such as this there is only one valid reason for belief — that we have really firm evidence for such belief. I myself have been slow to allow myself to be persuaded. Almost more often than I can remember I have said: 'This once, this twice, this three times the phenomenon has been present, and the response has been seen, and duly measured; but what about the fourth, and the fifth time? I must see it again ... and again ... This development into a long-running search, over years, for greater and greater certainty about things which I thought I already knew. But soon the nature of the search began to change. The results showed me how little I in fact knew, and how much more complex and rich in mysteries the world is than anything which I expected or could possibly have imagined.

Suffice it to say here that whereas over the last ten years the *rhythms* of the plants have run almost exactly parallel with those of their corresponding planets, the actual *timing* of the

events soon began to vary, very slightly but consistently through the months and years. The discrepancy, if such we may call it, is always small in any one year, but it is consistent, and cumulative. It is always in the direction that the response by the plant comes a little earlier, and yet again earlier still, than the planetary alignment to which it is responding. It seems to be cyclic, with a period of just about seven years. And it seems to have the strange quality that it applies identically to all planets and all species growing, as far as can be found at the moment, in any part of the country.

We call this the phenomenon of the changing Phase-shift, because the planetary rhythms stay constant, but it is just the phase at which they are occurring which varies. I can give no explanation for this strange phenomenon; I did not expect it nor did I seek it; you may say that I did not want it (life would be simpler without it!); but it is there and I cannot ignore it. Over-riding as it does all choice of planet or species it would seem that it is something connected with the whole streaming of Time itself. It is as though we have two streams of time, one going slightly faster than the other, with this faster one carrying the realm of the plants in its embrace. And the difference between their speeds reduces to zero once in every seven years.

The human being as image

This picture of our universe as a unified living organism, permeated through and through by these twin streams of time, imperfect and inadequate as it is, is perhaps as far as opportunity will allow us to go in an article such as this. But it is only half of the picture as long as we exclude ourselves from it. For within us is another world, the world of the wonders of the human breast. And here again we meet with this

egg-like form in the ventricles of the heart, woven over with the spiralling curves of the muscle fibres. And when we come to study this wonderful organ, specially with regard to the manner of its beating, we immediately find ourselves immersed in an inner world of interpenetrating rhythms bearing strange resemblances to those of the great outer world of planets and plants. But here everything is inverted, and introverted — inside out. Just as, when we turn our gaze to the stars and to the planets we must say: 'As above, so below' so as we look at Man and his world we must say: 'As without, so within'. We humans are intricately and inevitably interwoven with the world in which we live, and within which, as parts of the whole we each of us mirror forth the qualities of that whole.

It is interesting to note that as long ago as 1920 Rudolf Steiner in his lecture cycle *Man — Hieroglyph of the Universe* spoke of two opposing streams of time flowing through and past one another at different speeds of flow, and how, out of the difference between these speeds of flow one would be able to calculate the silhouette of the human heart. On that occasion he said he would not give the calculation, partly through lack of time but also because his audience would not have understood it. So, the moment passed, and this crucial calculation was not given to the world. Crucial, because until its rediscovery by George Adams some quarter of a century later none of the work described here could have been done. The difference between these speeds of flow (technically it is a ratio of their logarithms) appears in our calculations as the parameter λ , and with this to our hand we can begin to penetrate not only the inner qualities of the form of the heart, but also the remarkable way in which its seven-fold rhythms mirror those of the great cosmos without. We can start with the concept of these inter-penetrating streams of time within, and from here be led to the world of

stars and plants, where, in the mysteries of the changing phase-shift we again meet the idea of these two streams of flow. The fact that we are not yet able to see, with complete clarity, all the connections between them simply shows how much more wonderful this world is than the best ideas which we can bring to meet it. *Gratias Deo.*

Chaos Theory and Projective Geometry

Nick Thomas

Of God, Laplace said that he had no need of such a hypothesis; however in recent years the growth of the study of chaos seems to have turned the tables on him. Indeed we might say that rather than God being dead, Laplace is dead! The idea then current in science, and in one form or another ever since, was that the future of the physical universe is in principle completely predictable in a mechanistic fashion. Laplace said that if he could know the positions and velocities of all the atoms in the universe then he could predict exactly what would happen in the future for all time. However, this assumes that the physical universe is a giant mechanism obeying the rather convenient laws of mechanics that he assumed apply universally.

It is something of a travesty that the godless view of the cosmos arose because it was assumed that matter obeys ordered laws discoverable by the human mind, and in turn it was assumed by Sir Isaac Newton and others that those ordered laws operate just because the universe is divinely created! A good God would not build-in perversity merely to confound us. Yet the very concept that the physical universe operates on the basis of order alone has been severely challenged by the scientific notion of 'chaos.'

Chaos is often thought to be the state of the house after

a wild party, or the mind of a madman, or the aftermath of a hurricane. It may also be seen in the light of spiritual science to have another possible significance, as a state in which new sensitive influences may play a formative role in contrast to a stifling order prohibiting the emergence of anything new. The scientific notion contrasts with the traditionally conceived behaviour of a machine which behaves predictably. A clock depends on the regularity of the operation of its parts and the laws governing them, and a pendulum swinging in a small arc of about 10 or 20 degrees is completely predictable, as first discovered by Galileo when observing a swinging lamp.

Yet it is quite easy to construct a slightly more complicated pendulum whose behaviour is quite unpredictable. It is not just that we do not know enough to predict its future antics (literally!), but that no amount of knowledge would permit such a prediction. Laplace is dead! Why is this? Briefly stated, it is because the special pendulum has such a great sensitivity to the tiniest disturbances around it, such as slight air currents, that these continuously disturb its motion, having a much greater influence than the large scale laws of its form and construction. Not only this, it now seems that order and regularity are the exception rather than rule. Laplace is even deader! What order there is arises as something enduring among the chaotic tendencies all around, something that can survive all this in a kind of darwinism for the lifeless world. Quite apart from the impossibility of knowing simultaneously the motions and velocities of all particles in the universe, even if we did it would not help, for the chaotic would not thereby be banished.

It is sometimes erroneously stated that chaos has only been known about since its 'discovery' in the 1950's by a meteorologist named Edward Lorenz who found that his computer predictions of the state of the Earth's atmosphere

were not reproducible. However, the possibility was already known in the last century, and was certainly known to Einstein. Perhaps in earlier times it was hoped that it would not prove significant!

What about some real-world examples of chaos then? If you listen to a dripping tap, sometimes it will not drip regularly, but will depart from an even 'drip — drip — drip' to a 'drip drip — drip drip — drip drip,' or even become quite random sounding. The weather and the stock exchange hardly need emphasising, although it is a significant advance to realize that a mechanistic model of the economy is now not only difficult to achieve, but almost certainly unreachable.

The planet Jupiter has a large red spot that has intrigued astronomers ever since it was discovered by Cassini in 1665. It seems to be a stable feature of Jupiter's atmosphere, and it was thought that when the Voyager spacecraft took close-up pictures of it all would be revealed. In fact nothing of the kind happened, and the pictures the author has on compact disc of all the NASA photographs taken by the Voyagers show nothing but chaos on closer inspection. This is a paradigmatic example of chaos, where large scale order 'rides on the top' of chaos.

The weather, or more accurately the Earth's atmosphere, is another such example, for there is (believe it or not) long range order there too. The human heart can stop beating and enter a state known as 'fibrillation,' typically caused by an electric or other shock, which in fact is a chaotic state in the technical sense, as is an epileptic fit. The Earth's magnetic field has reversed itself a number of times in the past, so that at times a compass would point south instead of north. A careful study of the magnetization of rocks in core samples has shown this to be true, but no regular rhythm was to be seen. It seems that this is another example of a chaotic

system, operating (fortunately) over a long time scale. Rudolf Steiner indicated from his research that the present mechanistic-like state of the cosmos (at least to outer appearances) only lasts for quite a short time and will cease in the future.

So chaos is not merely an artificially contrived curiosity in the laboratory. It is a significant field of scientific research today, and in such circles 'order' is seen as boring while its synonym 'counter-chaos' is interesting! What is very interesting is the idea that a machine can be such that it is more sensitive to minute disturbances than to its own form, as though it is not contained within its form but is really part of the whole cosmos and only thus to be understood. The harnessing of cosmic forces such as Rudolf Steiner pointed to may be realizable by means of such a machine.

The advent of the home computer has made chaos research practicable in a way undreamed of before, and surely the Mandelbrot set (see Plate 1, opposite page 32) must have been seen by most people by now. It is mathematically produced by thousands of calculations that would be quite impracticable by hand. At each point the equations either 'settle down' (like a pendulum coming to rest) or they do not. If they do the point is marked white (in this picture), or else it is coloured according to how nearly it misses settling down. It can be a beautiful picture when coloured artistically. The edges are the most interesting parts, for there the demarcation between settling down or not is least sharp. In the middle there is no doubt, and in the blue areas the matter is quickly settled, but on the edges there is infinite prevarication. Magnification of minute parts of the apparent edges shows them not to be edges at all, but containing a wealth of detail, and this persists to enormous magnifications (easily achieved by computer, see Plate 2, opposite page 32). This is very reminiscent of Rudolf Steiner's finding that an etheric body has no sharp edges in the way a physical body

does. We find chaos on the edges, and a new field of research which studies such things is called complexity theory. Here the greatest possible opportunity for variation and the greatest sensitivity to minute disturbances exists.

A most remarkable aspect of chaos theory is called the 'chaos game.' More complex variations on the Mandelbrot theme can model many realistic-seeming real world complexes such as coastlines, mountain scenery, weather patterns and so on. This is where the scientific interest arises, for this field holds out the hope of understanding complex matters quite beyond traditional non-chaotic approaches. Any engineer will recognize the Mandelbrot set as describing pictorially the stability characteristic of a machine that happens to be described by the corresponding equations. So-called 'non linear' systems were in the past a pain that had to be lived with, while now they are of great interest.

Is it possible to start with such a picture and then find the equations that produce it? In some cases the answer is 'yes,' and the technique is unbelievably simple in principle. A mathematical theorem called the 'Collage Theorem' validates the procedure, and the paradigm for this is the fern leaf. In this area of research, forms crop up which contain themselves as parts, and some of the specks of dust in the Mandelbrot set turn out to be themselves Mandelbrot sets when magnified. A fern leaf contains its own image in its parts, and the technique is to set up the outline of the leaf on a computer screen, and then 'tile' that with smaller images of itself (see an example of such a 'tiling' in Figure 2.1). The computer program then uses the results to construct point-by-point those areas that are 'stable' in the sense described above for the Mandelbrot set. The result is actually an instance of a set called a 'Julia set' which is related to the Mandelbrot set. A developing sequence as the leaf appeared on the author's computer screen is shown in Figure 2.2. It

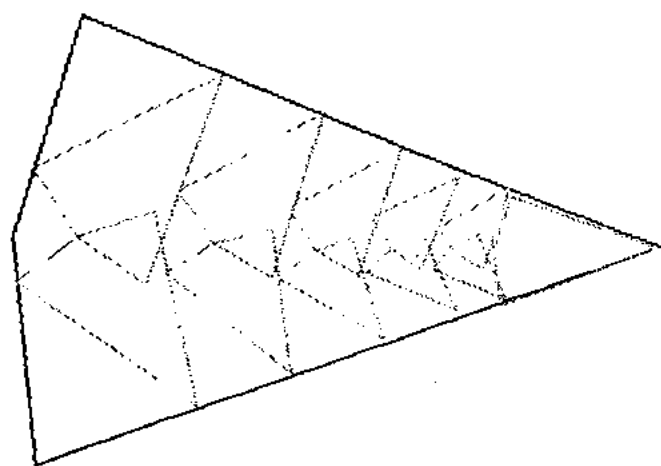


Figure 2.1. An example of 'tiling' where the image contains its own image in its parts. The result is actually an instance of a set called a 'Julia set' which is related to the Mandelbrot set.

bears a striking resemblance to how a photograph gradually develops when a scene is illuminated extremely faintly so that a very long exposure is necessary (Figure 2.3).

For long years Lawrence Edwards has done research in the application of projective geometry to living forms, as reported by him previously in this magazine, following the work of George Adams. Fundamental to this work are the so-called 'path curves' which arise in geometry in the most fundamental possible way. It is most interesting to find, then, that the Julia sets generated by the Collage Theorem can be seen as interwoven spiral path curves, the stable points all being on intersections of such curves. At a stroke the question of how a number of path-curve systems may interact, and with what result, is revealed. This may have far reaching consequences for physics, for the low-light-level exposure in Figure 2.3 is deeply connected with important aspects of quantum physics.

Until now it has been thought that quantum physics suppresses chaos at the smallest levels of matter, leaving it in the realm of the macroscopic. That may not after all be the case, for the work of George Adams (and Louis Locher-Ernst) in exploring geometrically Rudolf Steiner's discovery of negative- or counter-space enables us to see that just at the submicroscopic level the cosmos works through such counter-spaces. The question is how to relate many such spaces, and the Collage Theorem seems to be an important clue. As a vehicle for etheric forces we might expect counter-space to be related to systems containing their own images in their parts after the fashion of Goethe's idea that in the living world the whole is contained in every part. This is just what chaos theory and so-called fractal geometry are all about.

The author has further found that chaos appears unexpectedly (to him) deep within projective geometry itself when non-linear aspects of polarity are explored. The equation governing an aspect of the transformation, when applied in



Figure 2.2. A developing sequence as the leaf appeared on the author's computer screen.

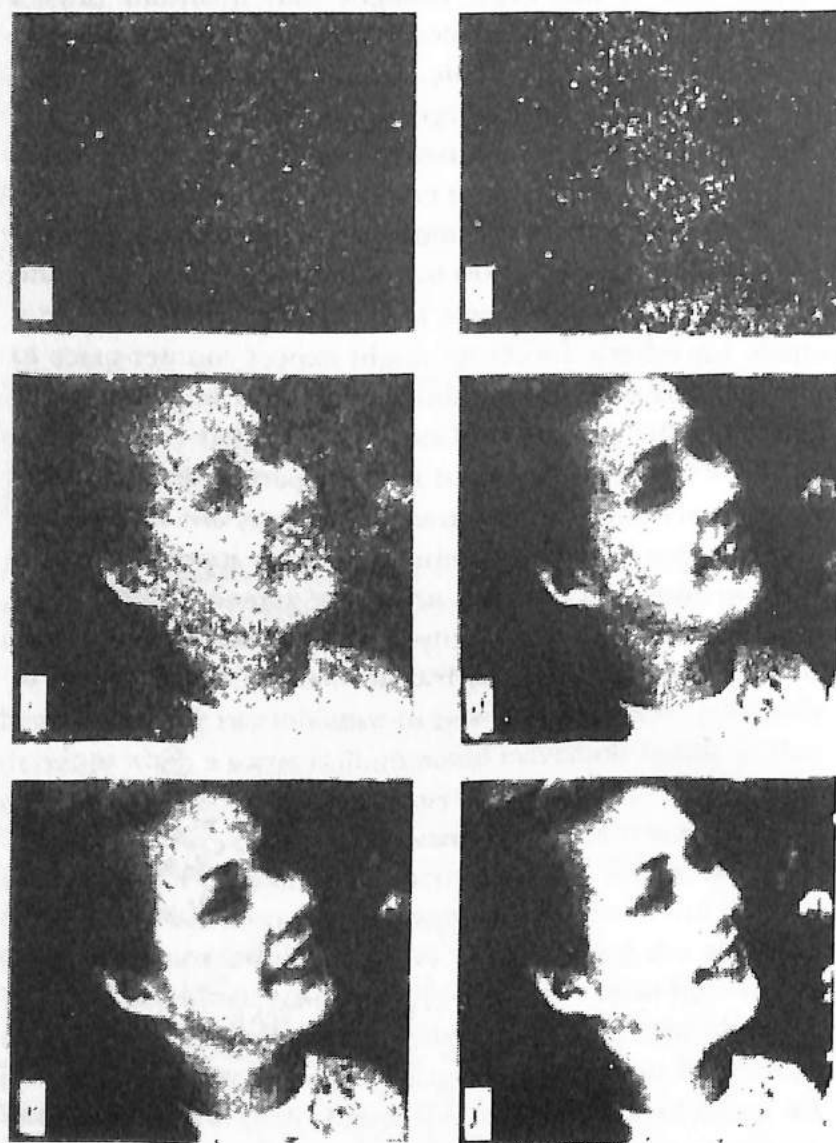


Figure 2.3. The previous figure bears a striking resemblance to how a photograph gradually develops when a scene is illuminated extremely faintly so that a very long exposure is necessary.

the same way as a much simpler one was to produce the Mandelbrot set, yields an equivalent picture (Plate 3, opposite page 33), and a magnified detail shown in Plate 4 (opposite page 33) clearly shows its 'fractal' or self-similar character.

This article is necessarily a very condensed account of a large and growing field of research which can fruitfully be allied with research into Rudolf Steiner's indications.

Our Heart

Sounding, Serving, Unifying

Philip Kilner

Shielded in the chest, the heart moves unobtrusively, night and day. It is strange that, even at rest, our bodies contain this centre of dynamic movement, in which muscle, valves and elastic vessel walls engage rhythmically with the pressure and flow of streaming blood. It is also remarkable that such a physically active organ seems to participate in the midst of the essentially non-physical: our emotions, our human judgment, our very being.

As in a musical instrument, some fundamental mechanical principles operate in the heart. There is an interplay of forces between fluid and elastic components. And, as in a musical instrument, these components, with their rhythmic movements, tensions and pressures, take part in the mediation of something else.

Different organ systems of the body are also involved, each in their different ways, in the mediation of non-physical human qualities. The full organic interplay may be likened to a living instrument or orchestra. But in this article, the aim is to consider the heart — an organ with a central, unifying role — and particularly its fluid dynamic origins and action.

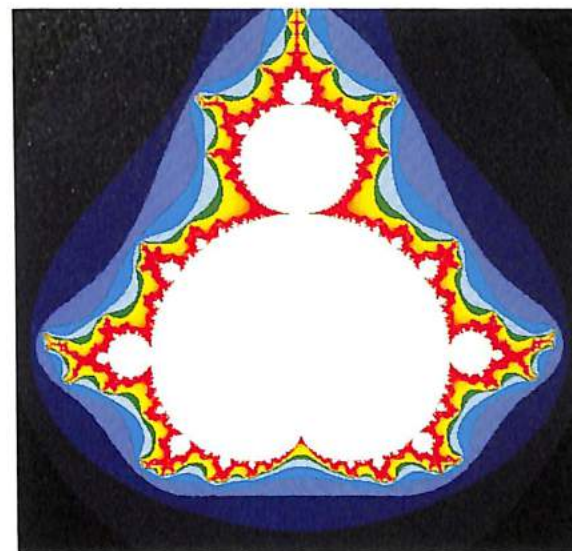


Plate 1. A Mandelbrot set.

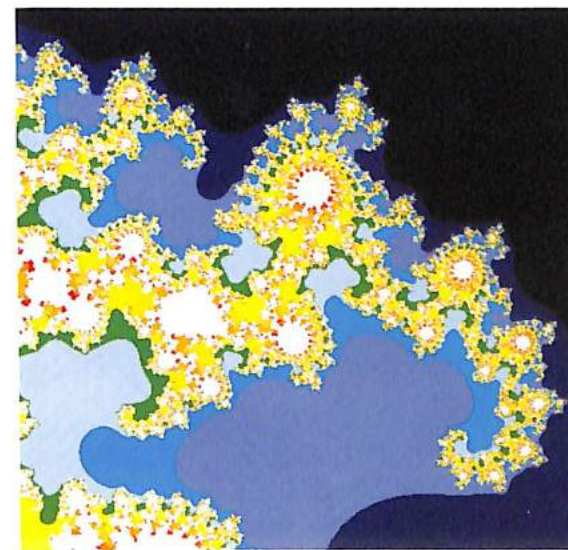


Plate 2. Magnification of minute parts of the edges of the Mandelbrot set in Plate 1 shows a wealth of detail.



Plate 3. The equation governing an aspect of the projective geometry transformation, when applied in the same way as a much simpler one was to produce the Mandelbrot set, yielded this picture.

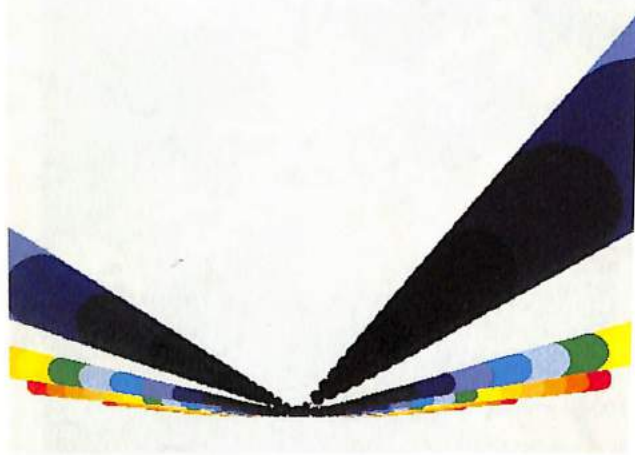


Plate 4. A magnified detail of Plate 3 clearly shows its 'fractal' or self-similar character.

The graspability of the heart's 'pump' action presents something of an obstacle to appreciation of other aspects of its function in our organism. But I think we should acknowledge at the outset reasons for the heart being likened to a pump.

Each of the human heart's two ventricular chambers has an inflow valve, allowing blood to enter via one of the atrial chambers from veins. And each has an outflow valve, allowing blood to be ejected into the great arteries when the ventricular muscle contracts against closed inflow valves. Effective movements of muscle and valves of the main (left) ventricle are absolutely necessary to sustain adequate pressure and flow in the arteries for the viability of various organs, particularly the brain and kidneys. It is the pump-like action of the heart that maintains the vigorous pressure and flow in arteries, giving force to the blood's movement out into the branches of the circulation, the finest of which are almost inconceivably small and numerous.

Just before the era when microscopes made it possible to see direct evidence of the delicate capillary networks linking the peripheral branches of arterial and venous trees, William Harvey, through dissections, observations and experiments, discovered much about the overall arrangement of the double circulation in man, and the paired pumping actions of the right and left heart. His dissertation, *de Motu Cordis*,¹ first published in full in 1628, displays the breadth and thoroughness of Harvey's studies in animals and man. A whole series of observations and arguments were marshalled to overcome long accepted misconceptions regarding the movements of air and blood in vessels. Harvey's contribution laid foundations for modern cardiology and heart surgery, and much of a heart surgeon's work (repairs of heart valves and blood vessel connections) follows from the need to sustain effective pump action at the centre of the circulation.

Operations go as far as heart transplantation. In transplantation, the failing heart muscle, with valves and immediate vessels, is replaced by a donor organ in such a way that the recipient's own blood circulation is once more connected and propelled. The recipient's own blood must also permeate and sustain the received organ. Naturally, re-establishment of this living synergy is not without difficulties, but it has been achieved many times. During surgery temporary artificial pumps, which may employ one of several distinct pumping mechanisms, are used to maintain blood circulation, and life, while the heart is being opened and repaired or replaced.

But what did Rudolf Steiner have to say on this subject? Here is a passage translated from the second of the cycle of 20 medical lectures² given in Stuttgart in 1920:

What is the generally held view of the nature of the human heart? It is regarded as a kind of pump propelling blood into the different organs. All sorts of intricate mechanical constructions have been put forward to explain the action of this pump device — the heart. Embryology quite contradicts these mechanical constructions, mind you, but the mechanical heart theory has not really been questioned or tested, at least, not in orthodox scientific circles.

What one should, above all, take into consideration when looking at the heart is that the heart is by no means what one would, in the first place, call a kind of active organ. Heart activity is not a cause; it is a result. You will only understand this if you take into account the polarity that exists between all the activities in the human organism which are involved with the intake of nourishment, and the further processing of nourishment, with its passage directly

or through vessels to the blood, and then follow the processing of the nourishment, so to say, from below upwards to the interaction that takes place between the blood that has taken up the nourishment, and the breathing that allows air to be taken in. If you take a thorough look at what is involved in this — one need only look at it thoroughly enough — then you will find that there is a certain way in which everything that lies in the breathing processes is opposite to that which, in the broadest sense is involved in the digestive process. There's something there seeking to be balanced out. There are things there which, I would say, thirst for one another and wish to be satisfied by each other. One could of course find other words to express this, but it will become clearer as we go on. An interaction takes place which consists, initially, of what passes between the liquified nutrients and that which is taken into the organism in the form of air by the breathing. This interaction must be studied exactly. This interaction consists of an interplay of forces. And these forces which play into each other find themselves held back before their mutual interaction in the heart. This originates as a 'damming up' organ [*Stauorgan*] between what I would call the lower activities of the organism — the intake and processing of the food — and the upper activities, the lowest of which is respiratory. A damming up organ is inserted and the most significant point is that its action is therefore a product of the interplay between the liquified foodstuffs and the air absorbed from outside. Everything that comes to expression in the heart, all that can be observed there, must be looked upon as an effect

which, in the first place, should be seen mechanically.

The only hopeful beginning that has been made towards examining the mechanical foundations of the heart's activity (though nothing more than that) was made by an Austrian Doctor, Karl Schmidt who published a paper on 'The Heart Action and the Curve of the Pulse.' There is not a great deal more to be found in this treatise, but one has to admit that at least there someone has noticed, in the course of his medical practice, that in the heart we are not dealing with a pump in the usual sense, but with the heart as a damming up device. Schmidt likens the whole process of heart movement and heart beat to the action of a water ram, set in motion by the currents. Therein lies the truth in what Dr Karl Schmidt has set out.

The paragraphs above deserve careful study. They do not amount to 'the heart is not a pump,' although they certainly suggest that it did not *originate* as a pump. They indicate that the heart's rhythmic action originates from motions of currents held back in their passage between the nutritive organs, on the one hand, and the upper activities on the other (Figures 3.1 and 3.2).

In this extract, Steiner did not specify which 'upper' activities he meant, presumably because his concern was to convey the heart's general situation between poles. The heart's situation can actually vary considerably: between species, during embryonic and foetal development, and, especially, through birth in higher mammals and man. For example, uptake of nutrients and dissolved respiratory gases are both via the chorion and placenta before birth, flowing in from 'below' the heart, with the growing brain, organs and limbs supplied 'above.' Once the lungs become functional with the



Figure 3.1. Human embryo, showing early heart development, about 22 days after conception, drawn from a scanning electron micrograph. Length would have been about 2–3 mm. The pericardial cavity has been opened to show the curved, swollen tube of the heart. Blood would have moved up this tiny heart, which had probably already begun to beat, on its way from the nutrient tissues of the yolk sac and chorion (removed from the front surface, central region) up towards the growing brain above. At this stage the heart tube has no valves.



Figure 3.2. Early developmental stages of the human embryo heart, viewed from front left, from about 18 to 20 days after conception. Blood enters from below and leaves by the branches above. The heart on the right is about the size of a pinhead, still without valves, although the bulges of gradually forming atrial and ventricular chambers can be identified.

first breath, however, respiration begins to operate 'above' the right side of the heart, although it remains, in a sense 'below' the left heart, with the nerve-sense organization 'above' that. Understandably, Rudolf Steiner avoided these convolutions, putting across, very expressively, the heart's functional location between the nutritive and the upper regions. In terms of biochemistry, several counter-processes can be identified in the organism — nutrition/respiration, respiration/metabolism, metabolism/excretion — with substances arising through localized processes that 'thirst' to be balanced by counterparts elsewhere. I think it is accepted in conventional biology that localized metabolic differences and needs underlie the existence of the blood circulation and heart. Rudolf Steiner goes further, in that he points specifically to a responsive, fluid mechanical origin of the heart beat. And his approach is not reductionist. For him, the polarities are not just physical, they are of the essence, finding expression in overall form and function as well as in chemistry.

After the section translated above, Steiner went on to introduce the idea of heart as sense organ, albeit subconscious, through which 'upper' activities sense the 'lower.' And in the *preceding* lecture, he had illustrated how fully realized, or retained, the upper/lower polarity is in the adult human organism compared with that of animals. In the human, the strong polarity is apparent in bodily form and posture. That first lecture of the series must have been one of the seeds for the classic Goethean study of Man and animals by Hermann Poppelbaum.³ I mention it because, although I am not going to attempt to draw essential distinctions between human and animal circulatory systems, overall bodily organizations can be recognized to manifest the most telling differences, as well as affinities.

Regarding the mechanics of heart function, Steiner was clearly scornful of too crude and simplistic an approach. I believe his way of expressing himself bordered, deliberately, on the provocative ... towards further investigation and thought.

Flowforms and trickles

My great interest in heart function began after my medical studies, and some years after first hearing of Steiner's challenging remarks about the heart and circulation. My real engagement with the subject began with what to me felt like a wonderful discovery. I was studying sculpture at Emerson College, and was being introduced by John Wilkes to Flowform design. We had used clay to shape Flowforms, which will be familiar to many readers as paired cavities that induce rhythmic, swirling movements in streaming water (Figure 3.3), and we were experimenting with flow in meandering clay channels. John said it would be interesting to see pulses of flow moving down a channel, and I began to wonder how

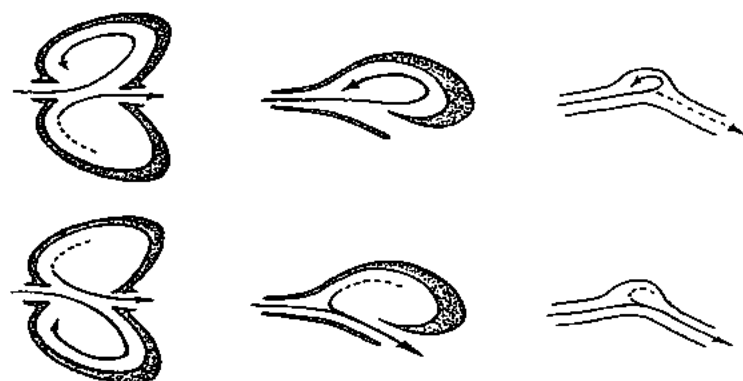


Figure 3.3. Flowforms and a pulsating trickle, viewed from above. In the double cavity Flowform (left) the inflowing stream curls back to deflect itself from side to side, with one cavity filling as the other empties. In the single cavity Flowform (middle and right) a filling phase is followed by an emptying phase. In each example, back-turning of the forward stream upon itself underlies the genesis of rhythm. (The trickle is drawn actual size, whereas the Flowforms could be as small as the drawings or very much larger.

we might set this up. It occurred to me that a single cavity, one half of the paired cavity Flowform design, might give rhythmically interrupted outflow. But when I first tried it, I could not get it to work. Then, a couple of days later, I noticed that a stream flowing from the end of a hose up a clay ridge on a sloping board was doing it! The stream was rhythmically building up along the ridge, curling back on itself and pouring down the board, repeating the cycle, so that the stream down the board flowed intermittently. I experimented with the positions of hose, ridge and board, until I was able to start again and shape a slightly more elegant 'single cavity Flowform,' which, on receiving a continuous stream gave rise to a pulsatile, rhythmically interrupted one.

It was at this stage that I really began to consider the flow cycle in a Flowform as a possible model of blood movement in a heart cavity. I later built single cavity forms on a much

larger scale, but at the time, discovery of the simple Flowform variant stimulated a series of small scale experiments, exploring the dynamics of pulsatile flow in shaped cavities. These led, in time, to collaboration with a heart surgeon on studies of flow dynamics in relation to operations for certain severe malformations of the heart, and later to studies using magnetic resonance imaging, enquiring into patterns of flow through living heart and great arteries.⁴

Early on, a second small, striking discovery gave support to the apparent relevance of the Flowform to heart development and function. John Wilkes had us experimenting with water streaming over waxed surfaces. Large streams raced down the waxed board, smaller streams meandered over it in an amazingly animated way, but a tiny stream would settle to a certain path, flowing steadily under its tube-like surface film. I found that careful shaping of a small trickle using a match stick, into a bend with a slight swelling, could lead to local, rhythmic pulsations of the surface, as if a small region came to life and pulsed (Figure 3.3). What happens in such a region is that the laminar flow of the trickle separates from part of the surface, and a little eddy current curls round and back, becoming slightly unstable. The eddy forms part of a dynamic cycle, driven by the forward current and contained by the tension in the curved surface, which gives rise to spontaneous pulsation — a small scale version of the Flowform phenomenon, and a liquid 'cousin' of the air flows that give rise to sound in a wind instrument.

What were those phrases of Steiner's? 'Everything that comes to expression in the heart ... must be looked upon as an effect which, in the first place, should be seen mechanically,' and '... set in motion by the currents. Therein lies the truth ...' (in Karl Schmidt's likening the heart to a water ram).

To consider the water ram analogy, I will describe the ingenious device: It is used for pumping water, perhaps to a home on a hillside from a stream in the valley below. It makes use of the kinetic energy of a fairly generous amount of flowing water to operate a valved system which forcefully raises a small fraction of the total downward flow.

The way it works is that water flows down a straight section of rigid pipe. At the far end of this it escapes up through a valve arranged 'the wrong way round' so that the valve slams shut when the escaping stream is fast enough. Sudden interruption of flow by the shutting valve causes a sudden rise in pressure. Water in the pipe is brought to a standstill, and pressure drops again, and so does the valve, and the cycle can repeat itself. The result is a repeatedly banging 'water hammer,' with tremendous fluctuations of pressure in the pipe. The peaks of pressure drive part of the water volume out through a second valved escape hole, this time with a valve arranged the right way round for forward flow into a 'Windkessel' pressure chamber containing a cushion of trapped air (included to help smooth the pressure and flow fluctuations) and on into a pipe leading up the hill.

But surely this is also a crude and awkward model for heart function? Taken alone, and too literally, it is quite inappropriate. In the heart, the valves are all 'the right way round' for forward flow. There are no straight, rigid pipes, and the early embryonic heart, to which Steiner alluded, makes its first appearance without valves. The relevance of the water ram model, according to Rudolf Steiner's comment, is that its rhythmic action is set in motion by the currents. This being the case, I very much prefer to take the pulsating trickle, or the Flowform (each set in rhythmic motion by the currents) as models for a responsive aspect of heart function. Both illustrate how a continuous, steady stream can spontaneously pass into a rhythmic flow cycle,

and the pulsating trickle demonstrates how the currents of the flow cycle can in turn move flexible containing walls, bringing the boundary as well as the stream into rhythmic movement.

The embryo heart

The simplest form of pulsating trickle is a bend and swelling which pulses spontaneously as its trapped eddy waxes and wanes in the forward stream. In all vertebrates (creatures with backbones: fish, amphibians, reptiles, birds, mammals and humans) the embryonic heart begins as a delicate tube-like structure, formed by the joining of a pair of vessels. This heart tube curves to form a slightly swollen, twisted, S-bend (Figure 3.2), the loops of which develop into the atrial and ventricular heart chambers. At a certain stage, the overall curvature approximates to a form which, in a non-living trickle, could well induce spontaneous pulsation. It is at about this stage, before the formation of any valves, that the heart is thought to start beating, with blood beginning to circulate. But which comes first? Is there flow round the circulation first, to which the bend of the heart tube responds with spontaneous pulsation, gradually taking up the rhythm with its own active contractility? I would love to know the answer, but it is not easy to be certain about the truth.

Living human embryos cannot be investigated at this stage. It would be about 16–20 days after conception, about the time when the mother may be aware that her menstrual period has not come as usual. The embryo itself would be a delicate formation of membranes, still only about two or three millimetres long, suspended in a sphere of supporting membranes. The outermost layer, the chorion, would be rich in tiny developing blood vessels in close proximity with the blood of the mother's womb. The human circulation has its

beginnings in and around a membranous drop which is embedded in the wall of the womb, well hidden from prying eyes.

The same cannot be said of a chick embryo's circulation. Aristotle is supposed to have peered down into an incubated, fertile egg, and marvelled at the tiny pulsing red spot which was the heart of the growing chick. So did William Harvey. It is not too difficult to do this, through a window made in the shell. Use of a low-power microscope makes the network of the developing circulation visible, spreading through the area of a disc over the uppermost surface of the yolk as it hangs suspended in clear fluid. The chick circulation begins after only a day or two of incubation, with the tiny granulations of blood cells moving through the net of delicate vessels, and the embryo forming at the centre of the circular network. The heart tube is forming on the ventral (front) aspect of the transparent embryo, located between vessels converging from the surface of the nutrient yolk, and the vessels flowing up to sustain the growing brain, spinal cord and other organs. But even in the chick, it is not easy to determine whether the blood or the heart move first. A few years ago I studied several incubated eggs, but I am afraid I only ever saw blood circulation when the heart was already beating. I never observed circulation start before heart pulsation, although this was what I was most eager to see.

Others, also following up Rudolf Steiner's remarks on the circulation, have described evidence of spontaneous movement of blood, independent of heart action, in the embryonic circulation of chicks,⁵ and also in freshly excised mammalian organs.⁶ Their reported observations of spontaneous blood movement were always in circulations, or parts of circulations that included microscopic capillary vessels. There is no evidence that what was observed was ever more than a gentle, seeping flow or a very small positive pressure

on the venous side. I suspect that if spontaneous blood movement occurs, it is dependent on weak interactions between blood and surrounding tissues which are active over extremely short distances. The capillaries that make up the varied networks of the peripheral circulation are almost inconceivably small, with diameters of about a fifth of a hair's breadth! Within such small dimensions, forces of gravity and inertia are negligible, and other more subtle, less familiar forces may dominate. But, in the intact, mature circulation, with the heart maintaining substantial flow, there seems little doubt that friction between blood and the delicate boundaries of small vessels greatly exceeds any locally active forward propulsive force on the blood. Careful attempts at pressure measurements in very small vessels in the living mammalian circulation have recorded, as predicted by the conventional circulatory theory, a gradual pressure drop from the arteries, through capillaries, to veins.⁷

I believe the evidence does support the conventional view that high arterial blood pressure, maintained by the heart's ejection of blood, is (in larger vertebrates, at least) the major force propelling blood around the circulation. But this does not exclude other more subtle, locally acting forces at capillary level, and it does not exclude a responsive aspect to heart function.

Whatever the truth may be about the beginnings of the circulation in the chick or human embryo, the more remote origins of the vertebrate circulation and heart must be even more difficult to determine. Or are they? Paradoxically, I feel more confident about which came first — circulation or heart — in evolutionary development. I feel sure that it was *not* the heart that materialized first. It is likely, on the other hand, that there were, and still are, primitive fluid circulations seeping round small invertebrate organisms without hearts. Gentle circulatory flow might well be initiated by the

movements of nutrients and respiratory gases along diffusion gradients sustained through metabolic processes. And there may be other delicate forces that can maintain an adequate circulation over small distances in a small organism.

These thoughts about the origins of the heart remain speculative. Many interweaving influences and processes, developments and regressions must have contributed to vertebrate hearts as they are today.

Dynamic elegance of the vertebrate heart

It is likely that peripheral and dorsal 'hearts,' similar to those found in present day worms, molluscs and insects, existed before the appearance of the localized ventral heart of vertebrates. I believe that the gradual refinement of the vertebrate heart — a heart located at the 'front,' between abdomen and head, characterized by the atrio-ventricular double bend — must have been crucial to the evolution/creation of the vertebrate line. The action of the more primitive peripheral and dorsal hearts could never, I think, be called 'dynamic.' The chambers, which in insects are arranged in a line up the body, have something of a milking action, supplemented by valves in larger species, directly effected by external bodily movement, but never capable of sustaining swiftly streaming flow and firm, pulsing pressure.

The ventral vertebrate heart is different. Its rhythmic action is emancipated from bodily movement. The movements of heart chambers are not directly affected by movements of the limbs and trunk, although the heart is certainly responsive to the needs of the body. It responds, for example, with vigorous activity when blood returns with increased flow and altered chemistry during exercise. Exercising limbs help to propel blood back to the heart by rhythmic compression of

valved veins. In the heart, the muscle tissue itself has a responsive aspect, the strength of its contraction being positively related to the initial stretch of muscle fibres. And this responsiveness may be 'tuned' by influences mediated via hormones (for example adrenaline) and the nerve pathways of the autonomic system. But the point that I want to emphasize particularly is the dynamic elegance of the vertebrate heart.

The atrio-ventricular double bend is uniquely suited for a dynamic, rhythmic redirection and enhancement of flow. When the ventricular loop is ejecting blood, the atrial loop fills, with a turning, swirling movement of blood. Flow into the atrial receiving cavities can be compared, to an extent, with the rhythmic flow cycle of a Flowform (Plate 5, opposite page 64). This flow cycle achieves a natural transition from more or less continuous venous return to the interrupted surges of flow which pass through the atrioventricular valve. This does not mean, however, that the atrium is only passive in function. Its walls contain muscle fibres with their own inherent rhythmicity, led by cells in a 'pacemaker' region. But the atrium is a fairly delicate, thin walled chamber, where flow cycles and muscular contraction may be quite sensitively attuned to one another. In the human heart, it is the right atrium, receiving blood returning from the upper and lower body (plus a smaller stream draining the heart's own muscle) that can be regarded as the heart's prime receiving chamber (Plates 6 and 7, opposite page 64). Its wall contains the pacemaker region of modified, rhythmically active heart muscle from which excitation spreads across both atria, and then down into the ventricular muscle.

It is the left ventricle, on the other hand, that can be considered the principal output chamber, with the weaker right ventricle wrapped round to the right and in front of it. The ventricles also contain cycles of fairly orderly flow, but

here the energy contained in the momentum of fluid (kinetic energy) is dwarfed by the squeezing strength of the ventricular muscle. Forceful ejection of blood does, however, have a dynamic consequence: as the ventricle accelerates blood into the aorta, the contracting chamber recoils, like the body of a swimming squid, propelled by what it ejects. You may feel this on your own chest wall, particularly after exertion — the apex beat of the heart results, in part, from the left ventricle recoiling downwards as it propels blood up into the aorta. If such an active, dynamic ventricle were arranged linearly, that is with atrium, ventricle and aorta lying in a straight line (like chambers of an insect heart), ventricular recoil would push back on the blood waiting in the preceding chamber, giving it momentum in the wrong direction for ventricular filling. With the double bend arrangement of vertebrate hearts, the opposite is true. Ventricular recoil now pulls atrial blood towards itself so that ventricular filling follows immediately and efficiently.

In other words, the turns and twists of the vertebrate heart allow exchanges of momentum and energy — a rhythmic pull and push — between atrial and ventricular muscle and blood. They also, like Flowforms, accommodate relatively stable cycles of flow. They are streamlined for coherent, secondary flow patterns which readily curl back on themselves in spontaneous, rhythmic cycles (Plate 5, opposite page 64). Neither laminar nor turbulent flow are really appropriate for the heart. The shapes and movements of heart cavities, and of the ventricular inflow and outflow valves, accommodate curling, vortical flows which carry and redirect the momentum of returning blood.

The stability of flow (avoidance of excessive turbulence) and the dynamic exchanges between muscle and blood become crucial during exercise. But they are also a key to the efficiency and continuity of the heart at rest. The heart

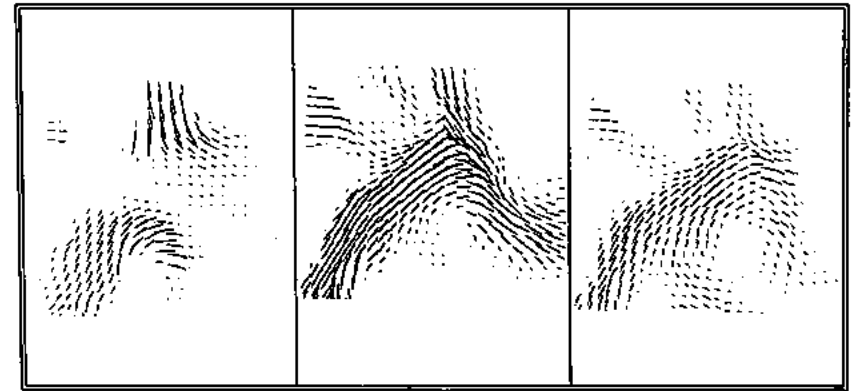


Figure 3.4. Blood flow into the right atrium, viewed from the right side, as revealed by magnetic resonance velocity mapping in a healthy volunteer. These three flow vector maps (out of a sequence of sixteen) show blood streams from above and below merging in a forward swirl as the atrium fills, just before the valve opens and the blood passes into the right ventricle.

continues its second-by-second work, day and night, beating about a million times per week, for all the years of a lifetime. This untiring reliability is founded on the flexibility and coordination of parts. Blood, muscle, valves, veins and elastic arteries are all mobile, pliable, and sustained in life — moulding organically to life's requirements. How different from the parts of 'man made' mechanical devices.

Heart movement swings between receiving and giving, responding and impelling. The atrial aspect receives and gathers up, until the curling streams and stretching muscle switch neatly over into the active, impelling wave of movement that is taken on more forcefully by the ventricles. The ventricles squeeze and sling the blood up into the arteries (Figure 3.5), where the heart's pulse is conveyed out to all parts of the body. Not least, the brain is continuously bathed in the rhythms of the heart, although this background presence rarely intrudes on our conscious awareness.

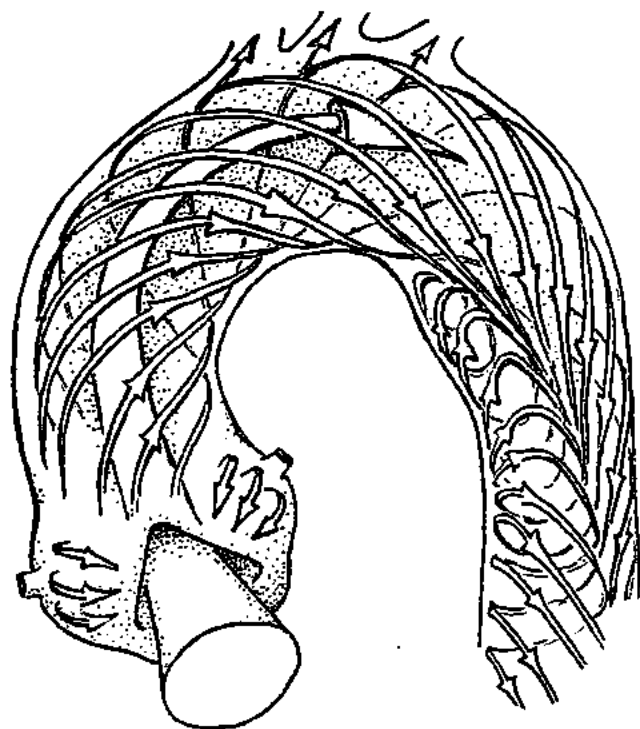


Figure 3.5. Drawing of flow in the aortic arch, viewed from the left. Flow patterns change through the heart cycle, and vary somewhat between individuals: this drawing, based on magnetic resonance studies of flow in healthy volunteers, represents typical late systolic flow. It gives a glimpse of the streaming movements traced by blood, which should also be conjured up when viewing the simplified drawings of Figure 3.3.

In the heart's cycle of activity, the two sides, left and right, are entwined, but distinct. The two streams move closely together, swinging round one another in their outward movement like partners swinging from the centre of a dance. They are dynamically linked — the more powerful left and the more responsive right — their flows separated only by a flexible dividing septum.

The heart and the whole

These dynamic, surging, entwined streams of the heart represent the midst of the double circulation, surrounded by both peripheries: the branches of the pulmonary blood vessels reach to and from the lungs. Surrounding the lungs, permeating the chest wall and all other parts of the body, are the arterial and venous branches of the systemic circulation.

The blood circulation does not really have the circuit-like arrangement often drawn in explanatory diagrams, although, functionally, blood follows the double, systemic/pulmonary circuits that are linked through the two sides of the heart, as William Harvey described. The branches of the arterial and venous trees are actually, like trees, volume-filling. The outflowing arterial tree of each organ occupies the same volume as the inflowing venous tree, with paired branches flowing counter to one another, side by side. The liver even has two out-flowing trees — arteries and hepatic portal veins, both passing over into the inflowing hepatic veins (with secretion of some fluid into a fourth set of branches: the biliary tree). Around the hollow organs, and in the retina of the eye, blood vessels are distributed more like creepers, branching to cover surfaces, but the principle of streaming and counter-streaming still applies ... except towards the finest branches, where transition from artery to vein is through one of a variety of capillary networks.

In the kidneys capillaries form the tiny hollow tufts of the glomeruli and also run as filaments, up and down the tubules, radially arranged in each kidney. In the spleen and bone marrow, there is a more open system of irrigating 'sinusoids' between loosely arranged cells. In the liver, cells and sinusoids are arranged hexagonally, a honeycomb of slightly chaotic, microscopically small irrigation regions.

The capillary beds of the body are inconceivably numerous, delicate, densely packed and varied. They are varied not only in form but also in 'taste,' each cellular environment exchanging characteristic 'flavours' with slowly seeping blood. The capillaries are so very numerous that, in spite of their minute size, their summed cross-sectional areas are very large — in total, several thousand times that of the great vessels emerging from the heart. Consequently flow is very slow in capillaries. There is a gradual slowing of the pulsatile flow out along arteries, a gentle seepage through capillary beds and sinusoids, and then steady acceleration back through the venous branches towards the heart.

The veins draining different organs carry blood of different chemistries. Major confluences bring together qualitatively different streams, which may flow fairly smoothly beside one another until the right atrium is reached. Here they swirl forward and down, slipping through into the right ventricle, then up through the pulmonary valve to the arteries, capillaries and veins of the lungs, and back through the left atrium and ventricle. All this results in thoroughly mixed, oxygenated blood emerging from the left heart for passage back to the various organs.

The heart is at the centre of multitudinous convergences and divergences of streams, a turning point and passing point: the conference centre of the organism. Blood gathering in left and right atrium at any instant in time was, shortly before, distributed throughout the lungs and the body, respectively. And what is ejected from the left and right ventricle a moment later will branch and permeate, it can be imagined almost cloud-like, to pass through the varied, delicate webs of peripheral vessels throughout the entire body and lungs. Then, transformed by passage through different organs, scattered and mixed in new ways, it is

gathered back through veins into the swirling stream moving through the opposite side of the heart.

This simultaneous out-streaming, in-streaming, and dynamic engagement at the centre is in you as you read this. Your heart is the ever-present, ever-moving meeting point of the diversity of your organism ... continuously sounding and serving your organism as a whole.

In this article I have used a range of models or metaphors in trying to describe the heart and circulation. But none should be grasped to the exclusion of others. The aim is appreciation of the reality, which, if only it could be seen, would be absolutely breath-taking. The movements of the heart accommodate a unifying continuity of flow at the centre of our physical organism. It seems strange ... and it seems natural, that this responsive/active gathering point should, at times, be experienced as central to our very being.

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Enhancing Sense-perception through Thinking

Olive Whicher

Life on earth today affords experiences concerning *space* as never before; there flood in on all hands pictures and experiences, which encourage spatial ways of reacting and thinking. This calls for ways of thinking, which come clearly to grips with the experiences demanded by life in a body moving around the earth-space. As children, we learn to stand upright, to cope with the law of gravity, rising above it in running and climbing. By observing the actions of others, we copy and try and try again, so that, all being well and in good time, we become proficient. The speed of modern life demands all this as never before, especially for those who live and grow up in cities.

Walking in the street, driving to work, hearing about or watching news of shootings, explosions, and rioting, even if only in the imagination — all this has an effect, particularly on the very young, which is of the same quality as the physical force involved in any of these activities. These forces, coming to expression through substance, originate from some centre and involve an outward movement towards a point of impact in the surrounding space. There is, however, a difference between an inorganic and an organic force. The first may be clearly and fully described by a physicist; not so

the force resulting in the physical movement of a living organism.

The modern analytical physicist is equipped through his education with the kind of thinking, such as that provided by algebra, the most efficient tool at the core of analytical mathematics, which takes away pictorial thinking and reduces the facts to symbolism. This kind of mathematical thinking has led to the most wonderful achievements in technology; life on earth has been greatly changed, with the development of telecommunication, travel, the distribution of goods all over the world, and so on. Significantly enough, though, the very pictorial element, which this aspect of mathematics has taken away, modern technology has given back in a very specific way in television, the pros and cons of which are not always evident to an indiscriminating public today. Not only the violence portrayed in the pictures, but the technological process itself, which involves the destruction of the original picture and its apparent reconstruction in the form of dots on the screen, has a detrimental effect on the life-forces of the viewer.

The development of the living sciences, with the notable exception of medical techniques in the operating theatre, and in methods of diagnosis, has not kept pace with the development of technology. Apart from important successes in immunization and certain aspects of biological control, disease threatens the extinction of plants and animals, and causes great concern also in humans. Environmental concerns point to a deterioration in the life of the planet itself, raising questions in the minds of eminent scientists in regard to the very nature of the earth. Is the universe simply a great mechanism, with relatively solid bodies moving round in the space occupied by all the other bodies, such as sun, moon, stars and galaxies, in ways which vary with the various theories? Or are there other ways of thinking about it all?

We see what we think we see!

A recent article in the *Daily Telegraph* (March 22, 1993) reviews the 'changing fashions' in theories concerning urgent environmental issues, in particular, the phenomenon of acid rain and the acidification of the soils. The article is accompanied by the head-on photograph of a pregnant cow, the sad face staring out from an enormously extended, heavy body, hanging from the horizontal vertebral column, supported by comparatively inadequate-looking shoulders and legs. The caption runs: 'Poor cow: manure releases ammonia, which ultimately turns to nitrate in the soil — result: acidification.' With this we are led to follow the origins of acid emissions from power generators to cow-pats, the product of a living organism. From such an analysis it would seem that there is no difference between the inorganic emission and the product of a living organism, such as has sustained life on this earth for thousands of years. It is of course, this very way of thinking purely quantitatively and materialistically about substance, whether inorganic or organic, which led to the chemical fertilizer industry in the first place, and of much else of an inorganic chemical nature used now in foodstuffs, pharmaceutical products, also of course, in clothing. What is the difference between organic products and synthetic ones? Maybe, in their wisdom, the poor cows are also asking this question!

Perhaps the very mind-boggling successes in the physical sciences arising through analytical mathematics have resulted in eclipsing the fact that mathematics includes quite other ways of thinking, the study and practice of which educates the mind towards quite different ways of approach to phenomena. Mathematics contains all manner of answers. The important thing is to put the right question, in order to get the right answer to questions concerning observed phenomena.

A question couched in thoughts, which will suit the phenomena of physics, will not necessarily result in a satisfactory answer to a question concerning living processes. In fact, we see what we think we see! Very much depends on becoming aware of the way we have been educated to think and, today, in taking our own thinking in hand and, where necessary, transforming it.

Transforming our thinking

To transform one's thinking so as to reach beyond the realm of measure, number and weight requires an inner moral force, and here the word 'force' has no spatial connotation, only an inner reality. The forces of will are still required, but the object is no longer in space. To quote Rudolf Steiner: 'The highest form of individual life is that of conceptual thinking without reference to a definite conceptual content.'¹ Here we are faced with an activity of will in quite a different world — in the inner space of our own spiritual activity of thinking. Thinking is an inner force, of which the human being through his own initiative is capable today.

Mathematics itself embodies this inner activity of thinking, and Steiner immersed himself in it at a very early age. But, while analytical mathematics, together with its offspring, the computer, has resulted in such a quantitatively assessed and ordered world, Steiner had already in the very early decades of this century seen the value of modern synthetic projective geometry, frequently urging the scientists among his pupils to look for the qualitative further development of pictorial mathematical thinking and imagination along these lines.

Essentially important in education, this aspect of mathematical and morphological thinking provides the key to an

understanding and a scientific description of what is involved in Rudolf Steiner's conception of the forces at work in all aspects of life. He saw these creative, formative forces as related to the sun and working through the elements of warmth, light, air and water into all substances and into the earth as a whole.

Such forces work contrary and are *polar opposite* to the gravitational force of earth, and the understanding of them involves the conception of a type of space, which is polar opposite to the three-dimensional space of the earth. If earth-space is centric, formed outward from the gravitational centre, *the living space of the sun is peripheral*; we think not of point-centres, but of planes and surfaces, forming and creating from the periphery inward. It is no easy task to understand scientifically what Steiner means by the 'etheric formative forces.'

The law of polar reciprocation

This law of polar reciprocation was formulated geometrically as late as in the first third of the nineteenth century and is expressed in the culminating theorem of modern projective synthetic geometry.² As indicated in Figure 4.1, the theorem states that for any line in the plane of a circle (or any of its transformations) there is a companion point (and vice versa). Line and point take on a mutual relationship. Move the one inward towards the centre and the other will move out to the periphery. Practise it and see that the polar line and its pole will meet on the circle itself and take on the aspect of tangent and its point of contact. We are also led to an ultimate conclusion, namely, that we must think of a line, which is polar to the central point, and that this line is *at infinity*.

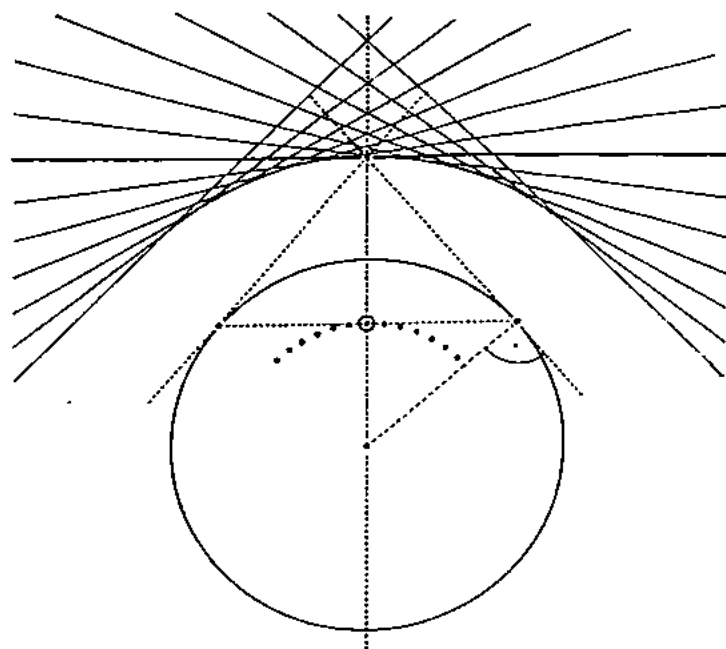


Figure 4.1. This illustrates the theorem which states that for any line in the plane of a circle (or any of its transformations) there is a companion point (and vice versa).

One appreciates an aspect of the circle, which complements the one-sided way we have usually thought of a circle — as the locus of a point, which, while moving round, maintains a fixed distance from a centre.

We see that a circle may just as well be created by its enveloping lines or tangents as by its points. Furthermore, the circle reveals an exact reciprocal relationship — an actual pairing — among all the points and lines, which lie in its plane. What a picture, involving the idea of social relationships!

Incarnated as we are in a physical body on the earth, the picture of a circle and its central point is very real. Each step

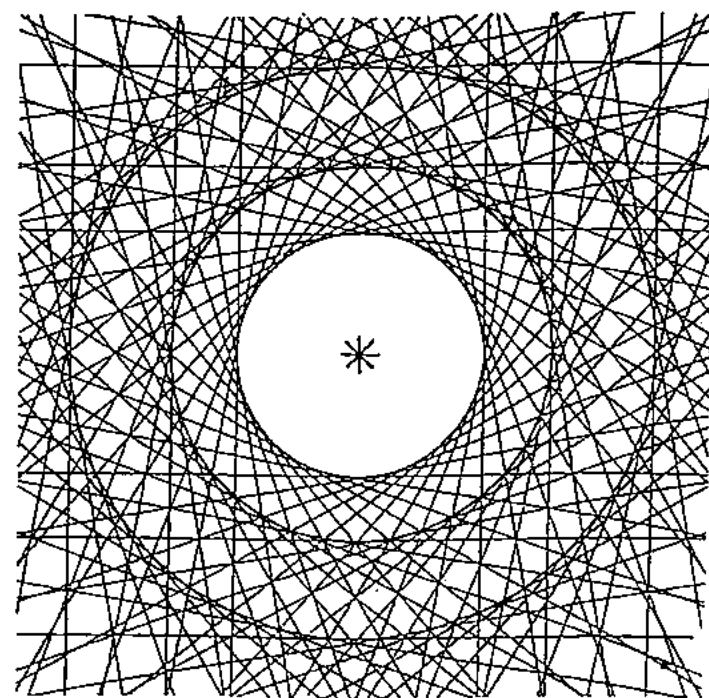


Figure 4.2. A family of circles formed by their tangent lines.

must be taken outward from a central point; wherever we go we carry our central point with us and, normally speaking, each step is of the same length. We are at home in this form of repetitive measurement, and can justifiably call it 'step-measure.' We build and we weigh according to this pointwise aspect of mathematics. The idea of *quantity* rules here.

Contemplate with the mind's eye the family of circles in Figure 4.2 and a new vista of thought is opened up. Not only are the circles so plastically formed by their tangent lines, but the measure which relates them to one another is very different. It involves two infinitudes; the outer line-at-infinity, and now at the same time, the innermost point also takes on

the quality of an infinitude. This point *functions as an inner infinitude*, because the measure between the circles is not additive, but it is multiplicative. In other words, the *proportion* between two consecutive steps remains constant, not the steps themselves. We call this 'growth measure.'

This is in fact the kind of measure to be found in all aspects of the living world, and it is especially visible in plants. Not only does the 'star-point' in the centre of Figure 4.2 represent an innermost essence of negative measurement, but also the tangential aspect of the circles, pictured plastically from without, gives the true image of the space into which, as Steiner described it, the 'formative forces' of the etheric world work. They pour creatively into the inner spaces, wherever new, young life is developing. These are not purely physical, earthly spaces; they are sunlike spaces, into which the life-giving forces of the stars and the planets can work. We begin to understand in modern terms the fact that in older times the inner organs of the body were related to the planets — heart to the sun, liver to Jupiter, and so on.

It is, of course, necessary to picture Figure 4.2 in its fullness, in terms of spheres, created by their tangent planes. Setting aside for our present purpose, the proof of this theorem of polar reciprocity, which a study of higher mathematics can bring, it can be said that it gives mathematical justification for the study of morphology in a way which is truly described by the word 'wholeness.'

The forces at work in living processes

It was Goethe's scientific method of observation, developed in the eighteenth century, and still not taken seriously by scientists, which Steiner recognized and developed further (himself also not being widely recognized as a scientist). We

should realize how new the task is: *to understand and provide a mathematically sound basis for the interpretation of the forces at work in living processes*. Materialism was, indeed, necessary, in order to reach a degree of freedom and individuality in thinking. Even the resulting technological civilization, belongs essentially to our time. Old beliefs from the past had to be overcome, in order to find truth at a different level. No dogma can help us today; but the way opened up by a mathematics which rests primarily on *synthesis* rather than *analysis* breaks very valuable new ground. Gradually, what appeared to belong to the past, takes on new life for science in the future.

What a picture this is, in comparison to the one provided in the textbooks of biology today! And yet, today, we shall still be understood, if we say that our neighbour has a heart of gold! Goethe, the great artist, who was also a scientist, went further and said:

'What is more splendid than gold? — Light — What is more refreshing than Light? — Conversation.'

Conversation! Only human beings are capable of it! The poor cow can only speak dumbly, hoping that we humans, by looking and perceiving and thinking more truly, will learn to hear. Words may echo to us seemingly from the past: 'Where two or three are gathered together, there am I in the midst.' These words belong to past, present and future. A 'sun space,' sun-circles are created, wherever human beings meet, as so many do today, attempting together to solve the world's problems. In recognition of each other's capacity for sacrifice, human beings are saying, 'Where there is a will, there is a way.'

Rudolf Steiner in a lecture cycle given in 1923³ describes how, if we go back to very ancient times, we find that human beings took very little notice of measure, number and weight in earthly things, for they understood the world through

their original clairvoyant capacities. They took less notice of measure, number and weight, but gave themselves up more to the colours and tones of earthly things.

'Just think!' he says, 'that it is only since Lavoisier, only rather more than a hundred years, since chemistry has been reckoning according to weights. The idea of weight is first used at the end of the eighteenth century!' Earlier humanity was given over to the colour-carpet of the world and to the weaving of tones and waves. One lived in all of this, even while one lived in the physical world.

Through this, he says, one had the possibility of seeing human beings, not as we see them now, but as the result of the converging forces of the whole universe. The human being was more than just the man standing on a little spot of earth; he was like a picture of the whole world, given colour from all sides. The harmony of the spheres sounded through the human being and gave him form.

Steiner goes on to describe how the picture given of the human form and of the human heart by modern science would have seemed to the teachers of the ancient mystery wisdom like knitting a stocking! They said: 'The human heart is the result of the gold, which lives everywhere in the light, streaming in from the universe and forming it. Light weaves through the world and light bears the gold. Everywhere the gold is in the light; gold lives and weaves in the light. And when the human being stands there in life, then is his heart made, not out of gherkins and salad and lamb-chops and the like, but it is created out of the gold in the light. The salad and the lamb-chop only serve to help us to learn that the human heart is created out of the whole world ...'

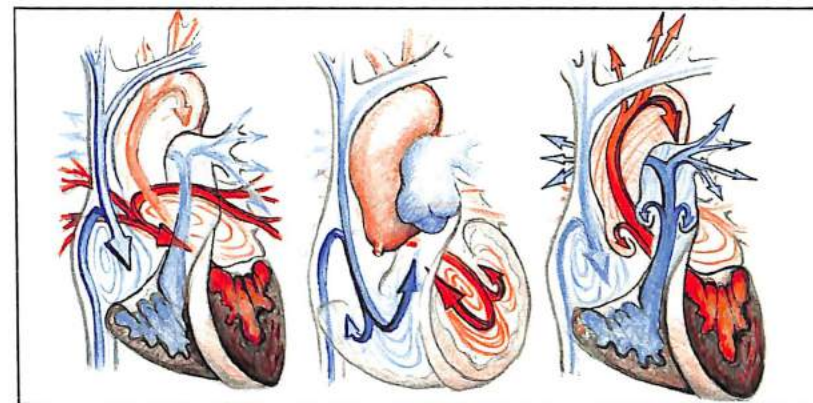
Perhaps it is easier to follow Rudolf Steiner speaking in this vein than it is to understand him when he was speaking to scientists and mathematicians, for there we allow poetry to come to our aid, whereas to transform our scientific way of



Plate 5. Between laminar flow and turbulence. Spontaneous formation of rhythmically alternating vortices in the wake of steadily moving cylinder (the fluid is a water/glycerine mix, with suspended aluminium dust for visualization). The rhythmic, vortical flow patterns are typical of blood movement through the heart. The central vortex pair in this photograph is similar to the pattern of movements traced by the blood sweeping into the left ventricle.



Plate 6. The blood spaces of the heart cast in resin, viewed from the front. Blue: right atrium, right ventricle and the sinuses of the pulmonary valve. Red: left atrium (behind, mostly hidden), left ventricle and the beginning of the aorta. Indentations of ventricular cavities are caused by banding or trabeculation of the innermost muscle layer, a feature that enhances the freedom of movement of contracting and relaxing of muscle layers.



Systole

Diastole

Systole again

Plate 7. Flow cycle of the heart. Simplified schematic drawings to show principle streams. The right heart propels oxygenated blood from the lungs to the body, whereas the left heart propels deoxygenated blood from the body back to the lungs.



Plate 8. Cassini curves: the lemniscate and the curves in and around it.

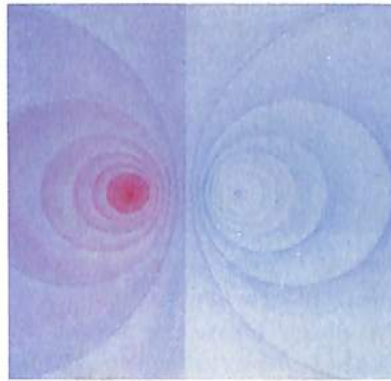


Plate 9. Apollonian circles, curves of division.

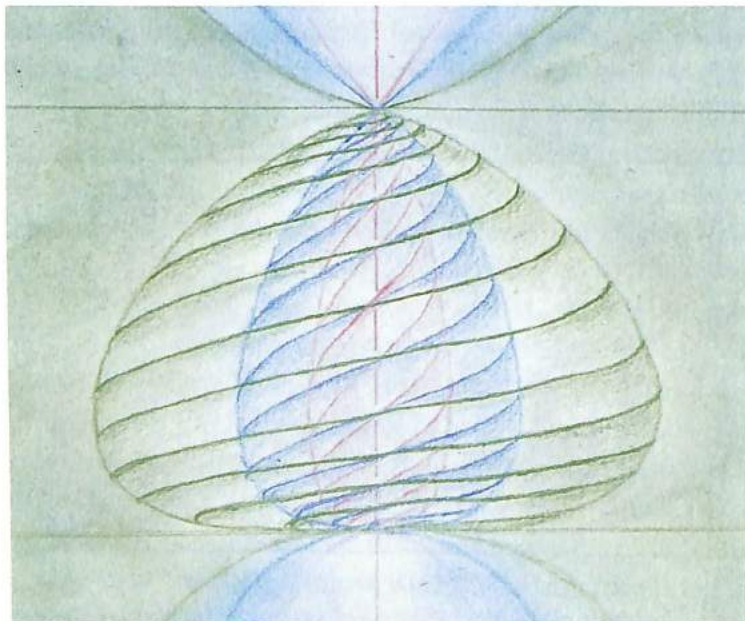


Plate 10. An example of a path curve.

thinking is much more demanding. Yet the mathematical thinking, which underlies the concept of physical and ethereal spaces and forces has proved to be a very fruitful way of approach to living phenomena, provided we use all three powers, which we have at our disposal: thinking, feeling and willing. The clarity of thinking must never be lost, always coming to terms with measure, number and weight. The light of thought becomes penetrated with the warmth of feeling called forth by the phenomena; and with the activity of willing we must press on across all thresholds of understanding. The intellect is our tool, but how we use it is our responsibility.

To stroke the warm rotundity of that extended belly of the cow helps in the perception of the creative worlds at work under the stars. In the many stomachs and inner spaces of bovine production within the living form, the forces are so different from what takes place on the factory production line! As scientists concerned with procreation in animal and plant and even in the realm of human thinking, we can learn to think according to the laws of the outer forms and *also* according to the quite different laws at work in the inner spaces of life, laws which accord with the way the celestial worlds work creatively into physical substances in physical space. Rudolf Steiner used the word *Gegenraum* (counter-space) to describe ethereal space.⁴

How to think differently

The key to the transformation of thinking required in order to move from the picture of physical space to that of negative or ethereal space is to change from thinking of points to thinking of planes or surfaces, *which mould forms from outside*.⁵ Practise putting surfaces in the mind's eye, instead of points.

See the beautiful, moving surfaces in water, the surface of a body which swims on water, the uniquely moulded surfaces of an individual human head or face. Draw them, model them, picture them, always in movement and change. In time we learn to see with the mind's eye more actively than before; we learn to *perceive in both spaces at once* — the space of measure, number and weight, and the ether-spaces of the living, moving forms. The convexities and concavities of a living form begin to become eloquent; thought is raised into the spiritual 'dimension' of the etheric body, which is linked, not to the gravitational centre, but to the infinite periphery of the world. Human thought itself is an etheric power, a spiritual power, which we must learn to use rightly today, in order to find our true balance.

The laws inherent in the etheric formative forces are peripheral, working inward into living, inner spaces, in contrast to the way substance can be caused to explode outward. *The life-forces, working inward, draw substance upward, contrary to the force of gravity.* In the plant, for instance, it is evident that enormous masses of substance are drawn upward every spring, providing food, not only for the body, but — we hope — also for the mind. These are real forces, and our scientific task today is not only to learn to understand how they work, but also to realize that in the very process of using them, we are working towards the necessary balance in scientific thinking. This is the task to which George Adams devoted his life.

Adams, who had originally put the question to Rudolf Steiner concerning the relevance of synthetic geometry, created many pictures and contributed much in writing towards helping to bring about a change of scientific thinking. A picture which is most helpful in the awakened study of plant morphology is shown in Figure 4.3. A horizontal plane is tangent to a sphere; on it is indicated a family of circles,

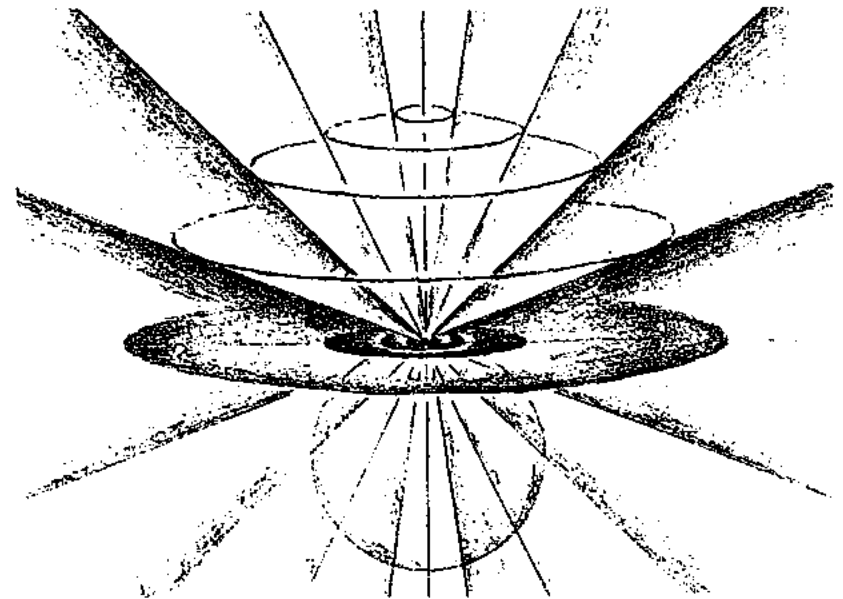


Figure 4.3. A horizontal plane is tangent to a sphere; on it is indicated a family of circles, which are concentric in the point of contact of the plane with the sphere.

which are concentric in the point of contact of the plane with the sphere. The circles in the plane are arranged in a measure, which is predominant in the plant kingdom. It is geometrical progression, in other words, proportional growth; we call it 'Growth Measure.' To each circle in the plane has been drawn its polar form — a cone, each in the point of contact with the sphere.⁶

Here we meet the need to go beyond the ordinary way of spatial thinking; these cones are not 'double'; each is a single cone, and it is deemed to be 'in' a point, for all its lines and planes are 'in' the point of contact, just as all the lines and points of the circles are in the horizontal plane. This is a quite new way of thinking, which cannot be fully illustrated in the picture; we need to employ active, pictorial and imaginative thinking to comprehend the dynamic of this picture.

Furthermore, our thinking must go beyond the limits of Euclidian space in realizing that *each cone reaches and passes through the plane-at-infinity*. Moreover, if the circles range in growth-measure between their innermost point and the line-at-infinity of the plane in which they lie, then we must see that in the family of cones-in-a-point, the innermost line will function as an *inner infinitude*, while, as the cones open out they tend to flatten towards the horizontal plane, *which then functions as an 'outer' infinitude in this planar type of space*.

To follow such processes is a valuable exercise in mobile thinking, which adds wings to our powers of observation. We learn to see what we think we see in two worlds at once, the material and the ethereal. In the physical movements of a living organism, such as the vertical human form, this way of human thinking, which also involves feeling and willing, gives vital access to Rudolf Steiner's descriptions of the worlds in which we live and make our experiences.

Rudolf Steiner, in his efforts to draw the attention of scientists to the necessity of thinking in this way about the way the etherical forces work, used as mathematical examples the Cassini curves (Plate 8, opposite page 65, the lemniscate and the curves in and around it) and also the Apollonian circles (Plate 9, curves of division), both of which are drawn between two foci, one being considered positive and the other negative. *Both of these curve families are, however, conceived only pointwise.*

Path-curve surfaces

George Adams continued his research after Steiner's death in 1925, until his own death in 1963. During the Second World War, while doing non-combatant service in the BBC, he was able to research intensively in the British Library. He

found work done by earlier German mathematicians concerning curves and surfaces in which the *quality of the tangent* (line or surface), is paramount and far exceeds the pointwise aspect.⁷

Adams was able to instruct Lawrence Edwards in calculating and picturing such curves and surfaces, for which he coined the name 'path curve' and 'path-curve surface' (Plate 10, opposite page 65). In later years, after the death of George Adams, Lawrence Edwards succeeded in applying this mathematical process to plant metamorphosis and also to the forms of animal and human organs.

In the early sixties, while working in the Institut für Strömungswissenschaften, which he helped to found together with Theodor Schwenk and other friends, Adams calculated a number of path-curve surfaces and had them made by the sculptor, John Wilkes, who with great skill was able to translate pages of figures into actual shapes from which he could make casts. This formed the seed-ground from which Wilkes was later able to develop his Flowforms, still with the aim of water purification, though without the underlying mathematics of the path-curve surfaces. This work, too, is being developed further now, with the aid of Nick Thomas.⁸

Quite recently, Adams' work with these higher order surfaces has been taken into the practical field by Georg Sonder, who has transformed the process, whereby the pharmaceutical firm Helixor creates a remedy for cancer. Instead of a cylinder, as previously used, the mixing process now takes place within the egg-shaped form of a path-curve surface. The indications given by Dr Steiner for this remedy ask for the mixing of the juices of mistletoe berries picked in summer and berries picked in winter to be carried out in some way *outside the influence of the force of gravity*.⁹ Cancer is an illness of our time, in which the formative and controlling influence of the etheric formative forces is weakened,

resulting in the physical proliferation of the cells. One solution was the centrifuge developed in Arlesheim, Switzerland, and used to create the medicament Iscador, with which Adams was also originally connected. In both methods, it is the anti-gravitational, etheric, cosmic force, which must be allowed to function, unassailed by the force of gravity, during the process of mixing.

It is fascinating to realize that the enormously varied shapes of birds' eggs are all mathematical path-curve surfaces — typically ethereal space-forms! The same may be said of the water-vortex and no doubt of the vortical eddies in the air, which are sometimes visible in the swirling leaves of autumn. Warmth, too, is a field of research, which responds well to this new way of thinking.

The laws prevailing in the realm of etheric formative forces are, indeed, peripheral and work in quite a different way from the forces described by present-day physics, which are inadequate and misleading when applied to living phenomena. Awareness is growing today that it is not the sacks of artificial fertilizer, nor the foodstuffs provided by the chemical industries, which promote healthy life, but that the earth herself is a living organism.

It is to be hoped that the science of the 'path-curve surfaces' will be further developed in techniques concerned with living processes; an example might be in the mixing of the biodynamic preparations. This way of thinking mathematically certainly helps to explain why Steiner gave instructions for making these preparations in the way he did.

Just as biodynamic farming methods take organic farming further, so also anthroposophical medicine, which is partly allopathic and partly homeopathic, reaches further than both. Our task reaches into the future, to build a firm bridge between analytical science and spiritual science.

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4. Steiner first used the word *Gegenraum* (Anti-space or counterspace) in the lecture course given on Astronomy and its relationship to the other sciences, 1—18, 1921. See also the *Warmth Course*, Mercury Press, Spring Valley, NY 1988.
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7. Adams discovered some little known mathematical work by Sophius Lie and Felix Klein and developed it in order to supersede the use of the pointwise Cassini curves and the Apollonian circles. He called the curves and the surfaces he was able to develop 'path-curves' and 'path-curve surfaces', and was attracted to them, because they involve a highly tangential and planewise way of thinking; ideally suited to the picturing of ethereal or negative space-forms. The surfaces in Plate 10 are pictured and must be thought of in this kind of space. They are poised between the vertical line, which functions as an inner infinitude, and the horizontal line-at-infinity, towards which the surfaces would develop, if the drawing were to be continued. One can imagine the whole of this ethereal space woven through and through with the planes, which mould the surfaces from without. At every point on every curve there is a hyper-osculating creative plane, which cannot, of course, be drawn.
8. See Theodor Schwenk, *Sensitive Chaos*, Rudolf Steiner Press 1963. John Wilkes developed the Wirbela Flowforms at Emerson College, Sussex.
9. Rudolf Steiner's indications concerning the development of a cancer remedy were developed after his death, by Dr Alexander Leroi in Arlesheim, Switzerland. This remedy, Iscador, is produced by Weleda in Switzerland. The pharmaceutical firm Helixor in Germany has developed another method of mixing the juices using a vessel created in the form of a path-curve surface.

Flow Design Research Relating to Flowforms

John Wilkes

Everywhere in nature we experience rhythm. If we consider fluid processes in outer nature, we repeatedly experience that rhythms constantly appear and disappear. With watery processes we have indeed a very transient situation.

The outer world of freely moving water although rhythmical is not one which can be held with any constancy. It is only when we experience living nature that these rhythms are really held within a firm organism. They can then be experienced in a very ordered and consistent way. For living organisms rhythm is an essential feature. As soon as it disappears, so does the possibility of living. There is no living organism which exists without rhythm. A plant, of course, does not pulsate but it exists nevertheless within a rhythmical context. And these rhythmical organ forms that we see everywhere, through which the fluids pulsate are built in turn with the help of the fluid.

The river bed for instance, is built by the fluid process from the simplest beginnings. And this meandering bed, which is an expression of the rhythmic tendency in the watery process, then itself regulates the flow. The flow process creates the organ which then regulates the flow. It is really an extraordinary thing and I never tire of pondering

on it. The heart too is created out of the fluid process which it then regulates in this most extraordinary way.

But what is this fluid process? It is such a mystery. What is water, what is blood? What is its real function? The way we deal with it today is a travesty of its life supporting function. Water is indeed used principally for transport, and energy production. In every way in which we use it we deteriorate its capacity to perform its real function, and this brings us to the question — can we work in such a way with this wonderful substance, that we know is right? Do we have a conscience for water?

Water is self-effacing. It sacrifices itself and is not able to protect itself. Its very function is to be open for everything. It is there to take into itself and mediate cosmic processes to earthly functions.

This is possible by virtue of the very fine and sensitive membranous structure that becomes evident when water moves. Water is not really itself when it is still. It mirrors its surroundings, we are unable even to see into it. In movement it becomes filled with magic, it becomes a mediating organ. This must be one of the most sensitive organs. Theodor Schwenk is at pains to demonstrate the existence of this inner structure of water in his book *Sensitive Chaos*. At every moment water is changing its quality of movement. This characteristic may be even more dramatic with a substance like blood. Through my connection with George Adams, I met Schwenk and his experimental demonstration of the 'vortex-sequence' phenomenon, which has been an ongoing inspiration to me (Figure 5.1).

The vortex-sequence is an ordered expression of what I call a vortical meander. The question prompted for me by this phenomenon was: would it be possible to create a vessel or indeed an 'organ' which would enable water to manifest this potential for order and metamorphosis which lies within



Figure 5.1. A vortex-sequence after the method of Schwenk.

it? Such a vessel would exist as an artistic statement between the inorganic and the organic, lifting the former towards the latter.

Would it be possible to create an organ which enables water to express and manifest its innermost potential.

Through experimentation I discovered that rhythm is generated by means of proportion. Surfaces cause resistance to water when it is gaining momentum by flowing down a slope. We remember the familiar phenomenon of water, forming waves as it spreads out over a sloping road. If a relatively narrow aperture is encountered, its dimensions determine whether more or less resistance is presented to the flow which might then be caused to hesitate. It is a very delicate set of conditions which lead to a self-inducing and self-maintaining rhythmical process. The wave rhythm is metamorphosed into a meander rhythm.

Having observed this rhythm-generating capacity of proportion, the next question was related to the nature of the surface itself which is intimately caressed by the fluid. What kind of influence might this have? A number of relationships present themselves : organism, rhythm, surface, time and also even place.

When watching all the extraordinarily complex movements that occur in water we realize they have principally to do with the vortex, left- and right-handed. These lead in turn to the meander, which is perhaps the most prolific of all forms and which is by definition asymmetrical. Taking this thought further in relationship to water's function of supporting life, we have to admit the strange fact that all the organisms that water supports tend in some way towards symmetrical forms. There are three qualities of symmetry; spherical, radial and bilateral. From asymmetry to symmetry we seem to move to a higher state: from the inorganic to the organic. Could it be that something might come of offering symmetry to

water? A meander could be mirrored to form a channel (Figure 5.2), which would consist of expanding and contracting sections potentially changing in proportion as the meander develops from the straight to increasingly curved form. It was this continually changing section which revealed the specific proportion that generated an unexpected pulse in my experiment.

There are three states of motion described as laminar, harmonic and turbulent. (Schwenk, Koehler, Schneider). It is in the realm of the harmonic/rhythmical that all living forms of nature appear, this extraordinary realm where proportions generate rhythms, rhythms essential to life. It is just this middle realm which is difficult to grasp, where with an increase in flow-rate there is a sudden change from laminar to turbulent and the middle is often missing. When it does appear it is held only by a very delicate balance. Having achieved the possibility of working with this narrow spectrum where rhythm appears, we have to ask how do we learn to work with rhythms in a positive and supportive way. Again and again test indications show something, even though not dramatic, usually pointing to a useful result.

George Adams had the idea of offering path-curve surfaces to water and I began building these in 1962. Introducing water to them proved however quite difficult. Firstly at that stage it was only possible to use synthetic materials and these had, it proved, a strong influence upon the quality of the water. Secondly gravitational and rotational forces were virtually impossible to overcome in the context of spreading water over the surfaces. The only satisfactory way to ensure an intimate relationship of water to surface made of an acceptable material was to construct a tube in stoneware ceramic. Due to the vortical form of the surface used it was possible to create a kind of pump through which water was

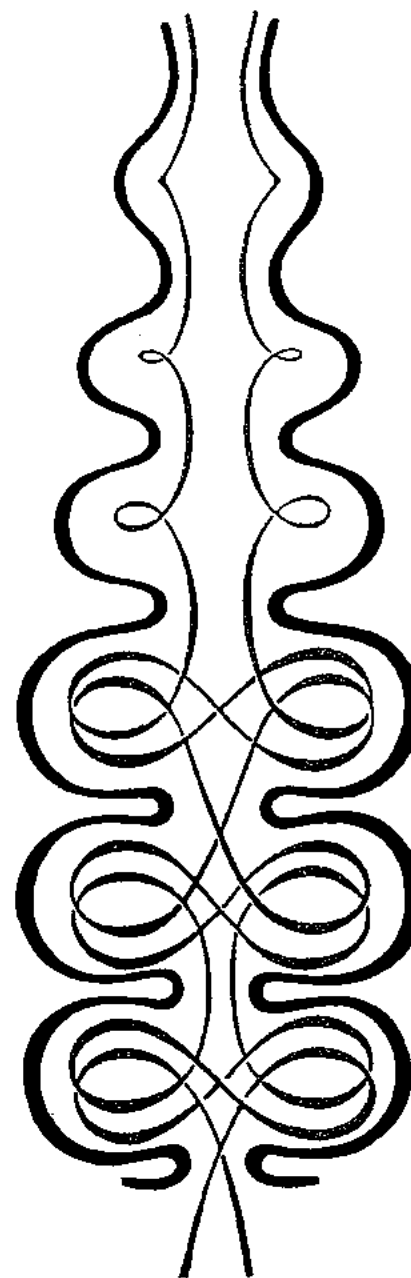


Figure 5.2. Diagram of experimental channel; the lemniscatory process is gradually achieved through the adjustment of proportions.

drawn up vertically while closely following the mathematical surfaces.

Since then it has been possible to construct apparatus consisting of a continuous vortical surface with a number of path-curve channels. Once primed, this functions as a pump, raising water nearly one metre while intimately caressing the proffered surfaces.

A short while after discovering the Flowform Method I was determined to investigate the possibility of introducing the path-curve surface into the Flowform. This was successfully carried out already in 1970. The streaming water passing rhythmically through a sequence of Flowforms, repeatedly passes over the surfaces built into the lateral cavities.

Since these first attempts Lawrence Edwards' research has confirmed the validity of Adams' ideas. With increasing certainty Edwards considers that the closer the organism achieves the ideal surface towards which it is striving, the more vigorous it is. It is clear from his work that water and surface combine to mediate the influences of the cosmos to the individual organism.

If we can achieve the goal of imbuing water with the necessary information in anticipation of its support of the organism, its life-sustaining capacities might well be dramatically enhanced. Having made this initial experiment with Flowform and mathematical surface it was necessary to proceed with investigating the Method itself.

The first priority was to establish the presence of a qualitative effect upon the water, due to rhythm. This rhythm was contained within surfaces built out of a direct experience of the pulsing water movements. Those proportionally related surfaces close to the central axis are most critical but all others have also to be designed to support and not resist the processes of rhythm.

The next step led to the building of ceramic Flowforms

reproduced from hump moulds. It was only a beginning and the movements were not as dramatic as had been hoped, due maybe to shrinkage and other variables: testing facilities were minimal but at least a start had been made.

During the mid seventies an installation for mixing biodynamic preparations was set up at Tablehurst farm, Emerson College, with the Järna Flowform in combination with a specially assembled Archimedian screw. It was on the basis of this work that the use of Flowforms among the farming community was explored in New Zealand. The possibility of spraying otherwise inaccessible hilly country by plane prompted the development of mixing techniques for large quantities. Mixing machines, designed as an attempt to reproduce the hand-mixing are being superseded by use of the Flowform Method. It is necessary to stir up to 2500 litres for an hour's flying time. During this first hour a second batch has to be prepared to ensure economic use of a plane during hired time.

Understandable arguments against the use of machine mixing, in which rhythms cannot develop, do not in my opinion hold for Flowform units. The human involvement necessary to design for the generation of truly rhythmical movements is very different from that of making a machine. With all three methods good results have indeed been achieved. Machines on the scale needed can however only be managed by groups of farmers and are excessively expensive to maintain.

Flowform units are in use on some sixty farms and gardens in New Zealand. As well as mixing preparations they can be used for treating water for animals, irrigation water for instance for seed germination and liquid manures. The units can thus be in use for all manner of purposes throughout the year.

As it is impossible to reproduce pictures of all the projects mentioned in the talk at Hawkwood and refer to the activities of the many people involved, a choice has to be made.

Warmonderhof Biodynamic Farm School was directed still in the early 80's by Jan Diek van Mansfelt who later became Professor at Wageningen University. He became interested in Flowforms and was instrumental in building a large research project. The concept was to build a kind of organ for the treatment of the sewage effluent from the polluted canal surrounding the site. The canal discharges subsequently into the neighbouring river.

There were to be two separate biological systems built in such a way that there would be a great deal of flexibility for research purposes. The two systems related to two treatment methods. One in which water was moved over a Step cascade, the other over a choice of Flowform cascades, the former generating a more laminar flow under gravity, the latter rhythmical lemniscatory flow.

A further goal was to compare Flowforms with each other as a step towards an investigation of means of optimizing the effects of the Method.

During four years research reports indicated significant differences in the biological processes of purification, but both methods were useful in oxygen uptake.

The more tardy and laminar flow in the Step cascade directed the purification processes in such a way that vegetative growth with an emphasis on wide-leaf production was stimulated in the pond ecosystems. This is to be compared with the condition within an overshadowed, slow-moving or downstream eutrophic part of a river system.

The macrofauna composition was biased towards species that prefer a darker habitat. They displayed a somewhat softer-rounded exterior shape, with slower movements and a life-cycle that includes a flying phase (midge larvae). Direct

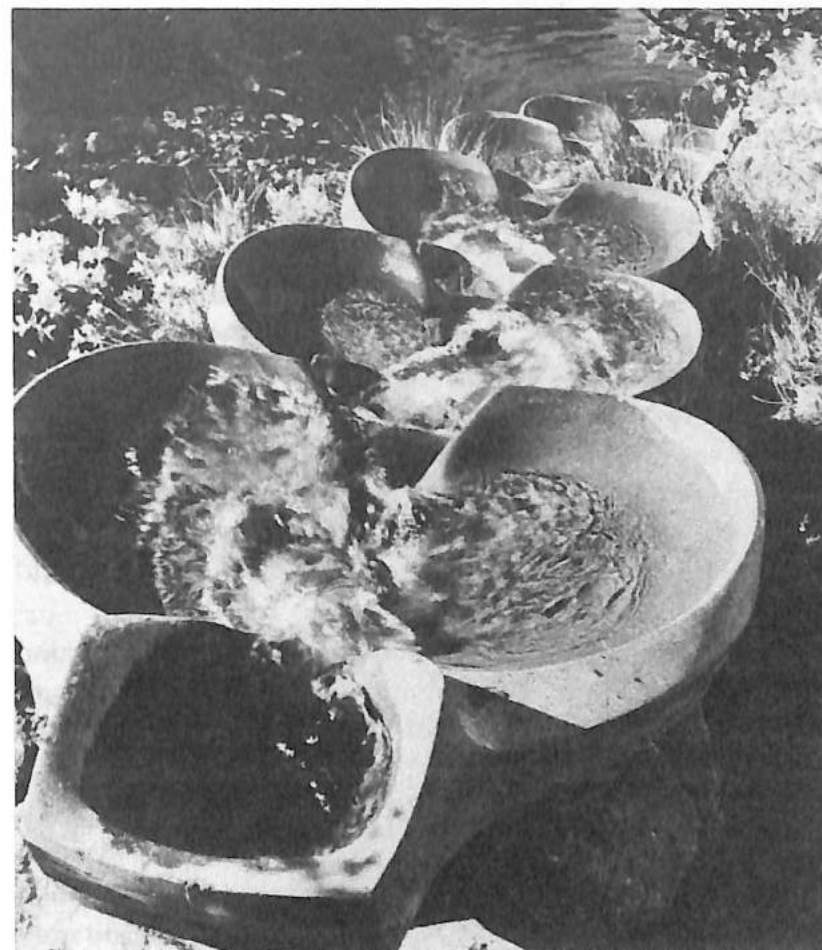


Figure 5.3. One type of Flowform used for research at Warmonderhof.

observations showed a tendency to higher turbidity and a smell like fug-must-ammonia. Tests carried out with the Drop Picture Method displayed a less pronounced structure. Gold-fish behaviour was slow and passive at the cascade outlet.

The livelier, rhythmically pulsating and turbulent water movements in the Flowform cascade stimulated blossom and seed production. Flowering proceeded earlier in the summer

while plants showed deeper colours in the autumn. Upright branching predominated with smaller leaf production. This is to be compared with the condition within the light-filled, open rapids and waterfalls, or the upstream, oligotrophic part of a river system.

The macrofauna composition was biased towards species that prefer a lighter habitat. They displayed a more pronounced and rugged exterior, with faster and more nervous movements and a life-cycle that remains in the water (crustaceans and water-mites). Direct observations showed a tendency to lower turbidity (clearer water) and a smell like humus or hay. Tests carried out with the Drop Picture Method displayed more pronounced structure. Goldfish behaviour was more active at the cascade outlet. A tendency towards higher oxygenation efficiency was noted but could not be proved in a satisfactory way.

Jan Diek van Mansfelt's comment was that where good quality water is needed for stimulating the development of higher organisms, Virbela Flowform systems could well be incorporated for positive effect.

The impulse to create the Warmonderhof installation was stimulated by the initial success of the lagoon purification system in Järna, where no comparative investigations could take place.

Arne Klingborg had observed the results of my first three years design experiments at Emerson College and invited me in 1973 to build cascades for the Seminarier in Sweden. This proved to be the first major installation with Flowforms (Figure 8). Over the last twenty years the installation has proved to be a very useful object of research and innovation.

In the meantime the work of Prof. Käthe Seidel created much general interest and experimentation with biological systems. My colleagues and I have had fruitful contacts over a long period from the late 70's. Our interest remains with

composite systems and the many different options they present. Basically the components consist of lagoons, filter-beds and cascades, used in very different ways dependent upon site conditions. Working with living systems demands continual watchfulness and willingness to change and achieve the overall balance and harmony for optimal functioning.

The Järna purification system has grown into a beautiful much visited wetland park, rich in aquatic, plant and animal life. There are some seven lagoons, a series of meandering gravel and plant filter beds with four Flowform cascades all of different design. It is open to the public with daily tours throughout the year, paths, benches, bridges, sculpture sequences and an attractive thatched shelter for sitting and bird-watching.

A completely separate second system has been built to cater for the Vidar Clinic and a new co-worker housing estate. This consists of a series of extensive ponds and two large cascades.

These early projects were the beginning of what is now a continually increasing preoccupation with biological systems of every kind. Much work has been done also in this country with the combination of reed-beds, lagoons and cascades. Systems have been built, from the single household scale, attracting for instance the interest of such a flexible situation as that at Highgrove, Tetbury, to ones for three to four thousand which are now being planned, and further, to a small coastal town site in Wales. There is also a very great range of pollution being managed, from highly toxic industrial waste in a successful pilot system for the Body Shop, through domestic and municipal to, for instance, swimming pool needs. It is possible to build chemical-free sustainable systems, vastly more user-friendly than the normal ones.

In Germany and Austria very beautiful solutions have been completed, presenting the overall impression of a natural

lake. Swimming areas can be defined but then surrounded by planted gravel areas. From the deepest point water is extracted, sucking out any debris, to be treated by circulation through an extra biological pond, and returned, regenerated and clean to the swimming area via a cascade.

Another closely related but rather more aesthetically orientated task is connected with interior design and the problem of air-conditioning. We have from Sussex been involved in at least two large commercial buildings in Amsterdam and Frankfurt.

Other quite novel directions have been taken more recently, relating to food-processing. Near Munich on an organic farm we now have cascades operating in connection with cheese and meat curing cellars. This rhythm-penetrated environment into which geopathic influences are drawn, is a modern attempt at reproducing the ventilation and ambient control based on traditional northern Italian methods.

Quite apart from all these more functionally biased tasks carried out in collaboration with professional colleagues who have requested our involvement, we continue to work on many projects concerned with enhancing the aesthetic quality of public and private environments.

One of the most recent installations we have been privileged to complete is that at Chalice Well in Glastonbury. This is especially satisfying with the Sevenfold Cascade connected with a healing spring from which water has been flowing for two thousand years and no recirculation is necessary.

Reviews

Mind and Matter. Imaginative Participation in Science, by Stephen Edelglass, Georg Maier, Hans Gebert and John Davy, Lindisfarne Press/Floris Books 1992. \$12.95/£6.99.

Two smiles begin this book, one seemingly scientific, the other personal, and perhaps more human. This can be seen as a symbol for the authors' challenge not only to the modern scientific view, but also to the modern way of life. Their thesis is to add participation to detachment; the latter being seen as the root of the ills of contemporary society and leading to a loss of meaning and a world devoid of human spiritual value. The authors say: 'We need a science which can embrace the warmth of smiles as well as muscular contractions which widen oral apertures, and which can include the inwardness of all the Kingdoms of Nature, of human beings and of the universe as a whole.' Thus we need a science that also develops human faculties in addition to acquiring knowledge.

A discussion of the deeper roots of materialism follows, where the very idea of naïve materialism is seen no longer to exist at the forefront of science, but yet a century of old materialistic science permeates our schools and society generally. Further, that science has become like the medieval Church: it would constitute the new heresy to doubt its truths. The authors then try to dispel the illusion that the fundamental concepts of material science — space, matter, force, energy and time — arise not as is supposed in the world 'out there' but in our own body experience, hence repudiating the idea that the observer is detached from reality. These concepts of the physical world, the authors claim, are derived from our basic sense experience of touch, somatic, kinesthetic and balance. These concepts lead to the mathematization of science and therefore to the one-sided and limited view that measurement is the primary criterion of science.

In the chapter 'Changing Relations to Physical Reality' a historical pathway is first highlighted with the example of gravity, demonstrating shifts in modes of thinking from Galileo to Newton. Linking Descartes

into this evolution of human consciousness, they show how the lonely self arose isolated within itself, while the outer world became a 'bowling alley for dead, solid, small particles of varying shapes, mass and size'; that is, a reality describable by mathematics. But the authors then show how the old mechanical push-pull view of the universe was challenged three times. First through the advent of gravitation as action at a distance, second by the fields of force of electricity and magnetism, and finally through relativity and quantum physics which challenged the simplistic view of the world as causal and the either wave- or particle-image of light. Each of these stages is seen as an incitement for the human mind to overcome its present mode of thinking and develop the ability to think free of sense-perception.

The authors then show how a new participative science can develop. A science which, because the scientist becomes truly awake to the totality of the possibilities he can select, enters into equilibrium, between the selected part and the whole. Taking the example of the wave-particle theory of light, they show how this apparent duality is an artifact of the model-orientated science. For them, wave-particle duality is not to be thought of as referring to a realm unobservable to the senses, but to two independent aspects of light relationships. More significantly, they say, this narrow model-mechanistic way of thinking leads to crises that are not only scientifically significant but also socially and environmentally.

In the chapter 'Science Coming of Age' it is shown how it makes no sense to speak of an external world devoid of human beings. The images of experience are 'an integral part of Nature's real existence,' but as an external world they cannot exist independent of human observers. The problem, it seems, lies in our habit that for something to be real, it must be out there and completely independent of us. Of course this begs the question as to the inner aspect of the world which we meet in concepts. The unity of the world as concept and the world as percept is physical reality for the authors. The apparent split between the two is due to the necessary organization of the human organism, not the world. The unifying of these two aspects educates and develops human faculties. It is not just information gathering.

Going on from this, the authors then show, drawing examples from biology and holism, how we must develop a science which goes beyond the physical world alone and cultivate approaches appropriate to the object of study. This requires the scientist to acquire the necessary

faculties. For the authors, we have a moral choice: either we can follow a purely reductionist science which leads to freedom but also to isolation, meaninglessness and power; or a holistic science which cultivates selfless interest in the single, individual, specific other, which leads to a healthy social life, and brings love to the world through freedom.

For me, the significance of this book lies in its social deed. The authors try to show how science, if it follows the right impulses which arise within it, can lead in a positive evolutionary direction. They show how one does not need to go outside of science in order to solve its problems. This is an important example to us all in various ways. First, to see how it is possible to make a real contact with events in the world, see the positive, and help them further. Thereby one significant abyss of isolation between factions of society may be overcome. Second, that all cultural processes have their own inherent health as well as being mutually healing. And finally, that everyone has the possibility of developing faculties to link the destiny of general culture with that of anthroposophically born initiatives. As the authors say, that is our moral choice.

Robert Rose

Catching the Light. The entwined history of light and mind, by Arthur Zajonc, Bantam Press 1993. £16.99

What is light, and what is sight? Zajonc (pronounced zience) illustrates the elusive nature of both light and sight by reference to experiment and historical fact, sifting through many imaginations, not merely in search of the 'right' one.

In early times, says Zajonc, 'sight' involved a movement from the eye to the object being viewed. The soul of the beholder played a part in the process. The divine nature of light itself was asserted in numerous traditions: the Egyptian god Ra, Ahura Mazda and Angra Mainhu (Ahriman), Genesis, Lucifer and the temptation, the incarnation of Christ; and Mani whose task was to free the light from Ahriman's clutches. And so on to St Francis, Plato, and Grosseteste, the idea that

everything material is condensed light. We even find Louis Kahn, architect, saying in 1973: 'light is the maker of all material.'

In about 1412 Brunelleschi first used perspective; what had changed to permit this new insight? Zajonc suggests that a new science of the physical had emerged at the expense of spiritual awareness. Western man had moved from a religious insight to a scientific one. Even today, however, some cultures find perspective impossible to see!

Reflection, refraction, diffraction, polarization. Which properties does light have in common with sound, water, electromagnetic radiation, waves and particles? Is there an ether, and if so are its properties as elusive as those of light? Enter Michael Faraday, Einstein, Kelvin and Tyndall. While electricity and modern physics provide new answers, they also raised new questions.

Descriptions of optical phenomena fill the pages: coloured shadows, prismatic fringes, the night spectrum. The rainbow, too, comes in for its share of scientific and spiritual analysis, and a simpler explanation of this complex phenomenon, with secondary and ephemeral arcs, would be hard to find.

Zajonc describes his introduction to Goethe, by Michael Wilson in Clent. Goethe's peers rejected his ideas as unscientific — today's scientists may be less sceptical. Wilson also introduced Zajonc to Steiner for whom 'the treatment of light became a paradigmatic instance of the deep conflict he felt between his scientific training and personal spiritual experiences.'

Max Planck, Millikan, Maxwell, Our Lady of Fatima, aurora borealis, lightning, sunspots, Heisenberg, Schrödinger, Bohr; these and many other references feature in the closing chapters which open out to give relativity a fair innings (another incredibly complex subject, Einstein's brain-child, clearly explained). Zajonc's command of the most recent theories on light and colour is clearly demonstrated in the later chapters, where he cunningly interweaves spiritual and historical questions into the scientific riddles of today. The invention of a single-photon source has led to new experiments: interference fringes, delayed choice; revealing, among other paradoxes, the peculiar properties of 'twin' quanta 'transmitting' information to each other instantly by no known physical means.

Catching the Light is an exciting book to read, and the average scientist will encounter an unusually broad range of references. The anthroposophist, the historian and the generally curious should find

a wealth of stimulating material, brilliantly annotated and indexed. The writing is accessible to anyone with a yearning to understand and a modicum of physics. It is a 'biography of light' written by someone who has clearly been in love with his subject for a long time.

Bruce A R Jackson

The Philosophy of Freedom by Rudolf Steiner, translated by Rita Stebbing, Rudolf Steiner Press, Bristol 1992.

Of Steiner's books, *The Philosophy of Freedom* occupies a special position, according to its author. It is the book he most frequently mentions in his subsequent lecturing career. This book 'will outlast all my other works,' he claimed. Nineteen ninety-four is the centenary of Steiner's *Philosophy of Freedom* and the bicentenary of Schiller's *Aesthetic Letters*, frequently appreciatively mentioned by Steiner. Do we need either text today? Both 'manifestos' of these great spirits originated at important stages of their own lives (Schiller was thirty-five, Steiner thirty-three), and both writers championed freedom all their lives: the poet and playwright, and the spiritual investigator who started so much in science, art and religion *because* he remained independent.

Some people still dismiss *The Philosophy of Freedom* as 'too intellectual.' But many have come to see the unassailable importance of this book as the basis for social as well as intellectual life today.

The first English translation, published in 1916, went through several revisions, including that of Michael Wilson in 1964. Students would not be without his valuable introduction. Rita Stebbing's first translation appeared in 1963, and her invaluable essay *The Philosophy of Spiritual Activity as a Path to Self-Knowledge* forms the entire issue of *Free Deeds*, Vol.4 No.3 (New York, 1963). The book is not so much 'about' freedom; it is itself an *awakener*. Steiner affirms: 'In writing I subdue to a dry mathematical style what has come out of warm and profound feeling. But only such a style can be an awakener, for the reader has to cause warmth and feeling to awaken within himself. You cannot simply allow these to flow into you from the one setting forth

the truth, while you remain passively composed.' Such was the method of this teacher of humanity.

The question is sometimes raised that because the philosophical climate since 1894 has changed, the book should be rewritten. However, Michael Wilson maintains that the book is 'the crowning achievement of nineteenth-century philosophy.' Furthermore, many other English-speaking readers would suggest that creative responses certainly have been made, in the face of the later developments, for example, in the words of Owen Barfield, particularly his masterpieces *Saving the Appearances* and *What Coleridge Thought*.

Rita Stebbing has made important revision to the 1988 edition. She has opted for *The Philosophy of Spiritual Activity* as the main title, followed by 'A Philosophy of Freedom' as a subtitle. The other subtitle is also different. 'The result of observing the human soul as natural science observes nature' becomes 'Results of observing the human soul according to the methods of natural science.'

There are several improvements in the details of the translation. Chief of these: *ideal* is rendered as 'ideal'; *ideell* as 'conceptual.' The inspiration for which she pays tribute to Hans Gebert in her foreword.

Students of Steiner's basic texts have found that *how* he says things is as important as *what* he says. The pattern of the paragraphing and even in the numbering of sentences reveal principles of form. Nothing seems arbitrary. Unfortunately, not all translators are aware of this. Maud and Henry Monges preserve such features in, for example, their translation of Steiner's *Occult Science*; George Adams' translation does not. Rita Stebbing preserves the paragraphing, italics and so in of *The Philosophy*, though the quotations are inset in a different type (as in Wilson's translation) unlike the German editions.

Let us now take on detail from a sentence in Chapter 5, one which forms a certain climax. *Indem wir empfinden und fühlen (auch wahrnehmen) sind wir einzelne, indem wir denken, sind wir das all-eine Wesen, das alles durchdringt.* Now *Wesen* is written with a capital as are all nouns in German. The earlier English editions, including Stebbing's first, capitalize 'All-One,' too. This invites mystical interpretation. It was rightly dropped by Michael Wilson and Rita Stebbing then followed suit. Thomas Meyer, interestingly, reports W.J. Stein's account that, upon being questioned, Steiner conceded that a certain hierarchical being was obliquely referred to here (T.H. Meyer, *Clairvoyance and Consciousness*). Whether this detail is important or not, Meyer's

chapter on 'The Philosophy of Freedom as a modern Tao book' should certainly initiate new interest. He points out that Steiner aimed to show our thinking is *already* clairvoyant, and that it can be strengthened. It seems the very meaning of the word 'thinking,' could be demonstrably proved to undergo a development as the chapters of *The Philosophy* unfold.

Barfield shows that the universal law of polarity is a basic concept to Coleridge's system, or dynamic philosophy, indeed it is 'the basic act of imagination.' It will not surprise us (if we wish to advance from what Steiner calls 'cookbook' thinking) that this tension between opposites that produces a third entity, is basic to Schiller and Steiner too. The balance-in-tension between reason and instinct (Schiller's 'form-drive' and 'material-drive') produces the aesthetic state ('play-drive'), which is creative freedom. Steiner whole-heartedly approves. In Chapter 2 of *The Philosophy*, there is a tension between the conceptions of 'spirit' and 'matter.' The subsequent chapters lead the reader to a form of monism which sees the mutual interaction of both 'spirit' and 'matter' as two aspects of one world. This form of monism is itself the product of the tension between naïve realism and critical idealism. In 'cookbook' language it can be summarized as: the polarity of concept and percept equals reality. To recognize this reality in the idea is 'the true communion of the human being,' as Steiner says elsewhere. Now, an advance from cookbook recipes, however, is to recognize the aesthetic state, of becoming alive in the moment. Steiner turns to music at this point: his books are 'to be read like a musical score' (lecture on Spengler, July 2, 1920); with *The Philosophy*, our thinking produces the 'music' as the pianist, reading the notes, recreates a composition. This, says Steiner, involves 'inner schooling,' 'catharsis, a purification of the astral body,' which, as we know, is a function of music, and art as such. Now, all the arts in future are 'to become more musical,' and give more expression to the law of metamorphosis.

Goethean thought, the 'organicism' of Coleridge and others, Schiller's aesthetic state — all lead to a vision of the *whole* human being, and if we are not to be overawed by the prospects opened up by anthroposophy, we have to be centred. *The Philosophy* contains that which is 'necessary for anyone who seeks a sure foundation' for spiritual knowledge (author's preface 1918). This basis can *never* be a static formula to suit a static, isolated intellect. We are led through

seven chapters to see for ourselves, and we are *led back* again, changed, through a further seven chapters. We all feel isolated at times 'powerless' to *do* something about the state of the world. Yet, without experiences behind us, we would never be able to truly contribute. 'Freedom from ...' (whatever fixation or illusion) is the stage that leads to 'freedom for ...' (a new world).

In this centenary year, we might feel that Schiller and Steiner are hardly likely to become popular philosophers. The translation Schiller's *Aesthetic Letters* by Wilkinson and Willoughby (OUP) is unimpeachable, the scholarship excellent, and the whole work a mine of information for students of the German language and of German thought. Perhaps we could also do with a 'poor man's digest,' and be shown a key to the structure of these twenty-seven letters (they are arranged in threes).

Now, Steiner, it could be said, almost provided a précis of his own philosophy. His *Theory of Knowledge* at any rate is shorter than *The Philosophy of Freedom*. His avowed motivation was to overcome the Kantian contention of 'limits to knowledge' by vindicating Goethe's *anschauende Urteilskraft*, the perceptive power of thought or judgment. Thinking enables you to *see*. Steiner succeeded brilliantly on both counts. The result, as Rita Stebbing so wisely notes, is not a cookbook, but an invitation to living experience. 'All real philosophers,' Steiner claims, 'have been *artists in the realm of concepts*' Stebbing suggests the book is 'like a Greek temple to Apollo,' or Leonardo's *Last Supper*. I suggest it is also a magnificent symphony, that is, it is musically constructed. The awakening human being is invited to create his own future, and thereby contribute to the future of the world. Both Schiller's and Steiner's philosophies of freedom are formidable, yet certainly not 'too intellectual.' It seems they might have been wrested from the intellectual preconceptions entertained by intellectuals and the labels of non intellectuals. In other words, we do not have to be experts in philosophy to read either work. Study groups can be a help. Such a social activity is one way of working, despite the pessimist's views, for the ultimate victory of the pen over the sword.

What prophets do we need today? Do we reinforce our positions, or remove barriers? Can we create space for the spirit of transformation? Schiller's 'ideal human being' and Steiner's 'all-one being' certainly first has to be glimpsed within. But *all* talk of 'justifying the ways of God to man' thereby becomes superseded. The challenge of

fundamentalism today has first to be overcome by the individual, if we want a united *and* free humanity.

In this task Steiner's *Philosophy* remains a beacon, and we have every reason to be grateful to Rita Stebbing for her continuing work to improve the translation, and for this new edition that marks its centenary.

Alan Stott

Notes about the authors

Lawrence Edwards, a Waldorf teacher for many years, is currently researching the relationship between plants and planets.

Nick Thomas has a background in electronic engineering. He is General Secretary of the Anthroposophical Society in Great Britain.

Philip Kilner works at the Royal Brompton National Heart Hospital in London where he uses magnetic resonance to investigate heart disease, and to study blood flow through the healthy heart. His approach draws on his studies of sculpture and Flowform design with John Wilkes. One of his aims is to show to specialists and non-specialist the beauty of blood movement in living circulation.

Olive Whicher is author of *Projective Geometry* and lectures at Emerson College, Sussex.

John Wilkes, a co-founder of Wirbela Flowforms, also researches and lectures at Emerson College, Sussex.

CHAOS, RHYTHM AND FLOW IN NATURE

Chaos and complexity theory, theories of form production in nature, the intricate and powerful workings of the human heart, the mediating properties of water in flowforms: research in all these areas is gradually building up a 'sensitive science' on which future generations may literally depend for survival.

The Universe as Organism in Space and Time

Lawrence Edwards

Chaos Theory and Projective Geometry

Nick Thomas

Our Heart: Sounding, Serving, Unifying

Philip Kilner

Enhancing Sense-Perception through Thinking

Olive Whicher

Flow Design Research

John Wilkes

Cover photo John Wilkes

