

What Are Natural Systems, Actually?

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Abstract

To this day, the applicability of abstract, definitive logic and mathematics to natural systems is rarely challenged or even questioned. Consequently we find ourselves predominantly living, working and researching in a way that contradicts how we naturally are in the world as it naturally is. This seems unwise, to put it mildly. In such circumstances can it be any surprise when we are drawn into needless conflict and misunderstanding, unable to work out what it means to live in an ecologically sustainable way, and prone to inflict profound psychological, social and environmental harm on ourselves and our natural neighbourhood? A way out from this predicament is offered by what has been called ‘natural inclusionality’, which has the potential radically to transform human understanding of natural systems and our place within them.

Keywords Boundary perceptions, evolutionary process, flow-geometry, intangibility, natural inclusion, place-time, receptivity, space perceptions

1 Introduction: Abstract and Natural Perceptions of Space and Boundaries

By imposing non-existent rigid structure onto naturally continuous space and dynamic boundaries, and enshrining this within three dimensional planes set at right-angles to one another, abstract mathematical logic engenders profound paradox[1-3]. Natural space cannot be confined within a box-frame, nor can it be cut into discrete segments that can be moved around independently and/or relative to one another. Natural space is infinite at all scales - i.e. dynamically distinguishable into different localities, but not divisible into separable, discretely packaged units or quantities. By the same token, natural boundaries cannot cut, they can only dynamically configure space. To cut space, as abstract models require, they would have to be reduced to zero thickness, and hence be nowhere.

This paradox of treating space and boundaries as rigidly definable fabric or structure is laid bare by the following statements:

“When a smaller box s is situated, relatively at rest, inside the hollow space of a larger box S , then the hollow space of s is a part of the hollow space of S , and the same “space”, which contains both of them, belongs to each of the boxes. When s is in motion with respect to S , however, the concept is less simple. One is then inclined to think that s encloses always the same space, but a variable part of the space S . It then becomes necessary to apportion to each box its particular space, not thought of as bounded, and to assume that these two spaces are in motion with respect to each other”[4].

“Space is another framework we impose upon the world . . . here the mind may affirm because it lays down its own laws; but let us clearly understand that while these laws are imposed on our science, which otherwise could not exist, they are not imposed on Nature. . . . Euclidian geometry is . . . the simplest, . . . just as the polynomial of the first degree is simpler than a polynomial of the second degree. . . . the space revealed to us by our senses is absolutely different from the space of geometry” Poincaré[5].

A moment’s contemplation reveals how utterly unrepresentative of the space and boundaries of our natural experience this treatment is. All we have to do is ask ‘what needs to be present for natural form to be distinguishable?’ Or, more concretely, ‘why is our direct experience of walking into a brick wall different from that of walking through an open doorway?’ Or, ‘what makes it possible to paint a picture?’ It then becomes apparent that the only way of answering these questions is to acknowledge the occurrence of at least two kinds of natural presence: a receptive context or medium which provides freedom for local movement and/or expression, AND local formative content, which informs or configures that context. The former is necessarily spacious, the latter necessarily cohesive. Moreover, for form to be and become distinguishable, each of these presences must naturally include the other. Spacious presence alone would be formless void, and formative presence alone would have no shape or size. They are necessarily distinct, but mutually inclusive presences. They can neither be abstracted from one another as independent entities, nor be homogenised into ‘Oneness’. The only way in which this necessity can be fulfilled is for one of these presences, natural space, ultimately to be everywhere, continuous, intangible (i.e. frictionless) and immobile, and for the other ultimately to be somewhere, distinctive, tangible and continually in motion. Natural space and figural boundaries are hence, respectively, continuous and dynamically distinct energetic interfacings between the insides and outsides of all natural forms as flow-forms[1-3].

In summary, natural systems are hence actually radically different in their dynamic, evolutionary organization from the self-contained abstract scientific models that are widely used to represent and simulate their behaviour, both conceptually and practically. This difference arises from the pre- and/or post-imposition of rigidly definitive structure in abstract models onto the spatial and dynamic continuity of natural flow-geometry. Such imposition is embedded in the foundations of propositional and dialectic logics and both classical and modern mathematics[1-3]. Whereas it has predictive utility in unchanging or repetitive systems, it cannot be expected to account adequately for the dynamics of evolutionary systems, where it has the potential to give rise to serious and damaging misunderstanding and miscalculation. In the latter systems a radically different, more natural approach is needed in which conventional discontinuous treatments

of space and boundaries are replaced by continuous ones. This more natural approach is available through the fluid boundary logic of what has been called ‘natural inclusionality’[2-3]. Here, I discuss the benefits of ‘naturalizing’ systems science using this approach to understand all forms as flow-forms - energetic configurations of space in space, displaying varying degrees of deformability, permeability and connectivity depending on context.

2 Natural Inclusionality

Conceptually, natural inclusionality is simply a way of understanding all natural evolutionary form or organization as flow-form, an energetic configuration of space in space. Implicit within this simple description are, however, two radical innovations in thought:

(1). The recognition that natural boundaries are intrinsically energetic ‘dynamic interfacing’ between distinct localities, not the ‘inert limits’ of discrete objects[1,6].

(2). The recognition that natural boundaries can only be dynamic through the inclusion of space as infinite, intangible, frictionless presence[1-3].

Correspondingly, the dynamic origin of all natural form as an energetic configuration of space can be understood in terms of an evolutionary process of natural inclusion: the co-creative, fluid-dynamic transformation of all through all in receptive spatial context[2-3,7]. This understanding differs radically from the conception of the evolutionary origin of biological species by ‘natural selection, or the preservation of favoured races in the struggle for life’[8]. It similarly challenges any notion of cosmological origins and expansion from an isolated locality. Such notions of ‘something out of nowhere’ are an abstract product of theoretically dividing or unifying space and form[9].

Natural inclusionality therefore calls for what amounts to a paradigmatic transformation - a radical de-framing and reframing of abstract perceptions of space and boundaries that have imposed non-existent definition onto naturally continuous systems for millennia. Such a transformation has profound implications for every aspect of our philosophical understanding of and relationship with Nature, including human nature: logical, mathematical, scientific, artistic, theological, linguistic, educational, social, psychological and political. The need for such a transformation was recognised by Polanyi[10] when he stated that: “For once men have been made to realize the crippling mutilations imposed by an objectivist framework - once the veil of ambiguities covering up these mutilations has been definitely dissolved - many fresh minds will turn to the task of reinterpreting the world as it is, and as it then once more will be seen to be”.

To summarize in general terms, natural inclusionality is a kind of awareness that helps us to appreciate our selves and other tangible forms as dynamic in-

habitants of Nature, not discrete subjects and objects rigidly set apart from one another. This awareness comes with recognizing that natural space is a limitless intangible presence everywhere, which permeates throughout and beyond all tangible expressions of energy, whether in the form of radiation or massy bodies. Natural space cannot be cut and can neither resist nor be resisted by nor be removed from the presence and movement of tangible forms. Far from being just empty distance between, outside or occupied by discrete material objects or structures - as is assumed by abstract logic - natural space is a receptive presence, vital for movement and communication. As natural dynamic inclusions of space, all forms are variably fluid flow-forms. Their boundaries are energetic configurations of space, not exclusions from space. When they move, they do not move through space; instead space permeates through them. With this awareness comes an appreciation of self-identity as an inclusion of neighbourhood - a fluid inclusion, not a rigid exclusion of others' identities. Our understanding of physical reality is such as to bring profound compassion for ourselves and other life forms, and is a source of deep inspiration and creativity. It calls for an expansion of conventional theoretical reasoning to include more fluid, artistic and poetic forms of expression.

In more technical and philosophical terms, natural inclusionality is a new philosophy and fluid boundary logic of self-identity and ecological and evolutionary diversity and sustainability. It is intended to supersede the abstract rationality that has dominated human thought for millennia, based on definitive logic that can only apply to inert material systems that are unknown to exist anywhere in Nature. Whereas abstract rationality treats space as empty distance between, occupied by or outside completely definable tangible material structures or objects with discrete boundary limits, natural inclusionality recognizes space as a limitless, indivisible, receptive (non-resistive) 'intangible presence' vital for movement and communication. This allows all form to be understood as flow-form, distinctive but dynamically continuous, not singularly discrete. The simple move from regarding intangible space and tangible boundaries as mutually exclusive sources of discontinuity and discrete definition to mutually inclusive sources of continuity and dynamic distinction enables self-identity to be understood as a dynamic inclusion of neighborhood. Intangible space is included throughout and beyond all tangible figural forms as configurations of energy, whether as massy bodies or mass-less electromagnetic radiation.

3 The Relationship Between Natural Inclusionality and Ecological Sustainability

The natural inclusional perception of living systems as flow-forms that receive, retain and pass on energy in the process of growing, living and dying is inconsistent

with any model of them as independent entities. To be entirely self-contained is to be an inert, hermetically closed structure with no capacity for take up or loss of energy between inner world and outer world. The nearest any life forms actually get to this condition is when they form survival capsules such as spores, seeds, pupae and cysts that carry them through periods of scarcity. This, by contrast with the Darwinian perception of survival by competitive exclusion of others, is what real biological 'survival' or 'preservation' entails. In such a dormant condition they are incapable of any active growth or relationship with others. But no sooner is any activity resumed that can support growth, so too is any life form's capacity to lose as well as take up energy through its necessarily permeable bodily boundaries and those of others in its vicinity.

It is therefore clear that the availability of sources of energy is the principal influence that governs the growth, organization and function of all natural forms of organic life as variably open systems. Any activity or pattern of development in which energy loss through permeable boundaries persistently exceeds energy acquisition will result in unsustainable deficit. On the other hand, any pattern of development that permanently prevents energy loss also prevents energy gain. For any living system to sustain itself, its primary need is therefore to be able to attune its activities and development to correspond with energy availability and hence with the local conditions of its habitat. This availability varies, both in amount and rate of supply, due to seasonal and climatic fluctuations, and where and in what form it is located. It also changes due to the growth, death and decomposition of the systems themselves, which respectively deplete and replenish supplies as they come under one another's simultaneous mutual influence. Real life does not, therefore, inhabit an even playing field of energy, space and time. Instead it continually both changes and responds to changes in the contextual circumstances of its natural neighbourhood in an improvisational process of autocatalytic flow, which gives rise to evolutionary and ecological complexity and succession[1,6]. Through this process of 'natural inclusion' an opening is made dynamically for an extraordinary diversity and complexity of interdependent forms and patterns of life to co-evolve over myriad nested temporal and spatial scales. The breathtaking variety that we can find in a crumb of soil, a patch of chalk grassland, a coral reef and a tropical forest comes into being under the guidance of no more and no less than the responses and contributions of its membership to natural energy flow in a natural 'sustainability of the fitting'[11-13].

Fig.1 illustrates the general principles arising from observations of how living systems (except modern human cultures) attune their patterns of growth and development to variable availabilities of energy sources. As natural inclusional energetic inner-outer interfacing of continuous space, the boundaries of real organisms, populations and communities do not remain constant throughout their

life span, but fluidly vary in permeability, deformability and contiguity (connectivity)[6,14]. They change in dynamic relationship with the availability of energy predominantly assimilated from sunlight into organic compounds via the process of photosynthesis, and rendered into chemical form (adenosine triphosphate) via the oxidative-reductive reactions of respiration as a form of combustion. Moreover, these changes themselves entail alterations in boundary chemistry induced by and involving shifts in availability and production of oxidizing and reducing power[6,15].

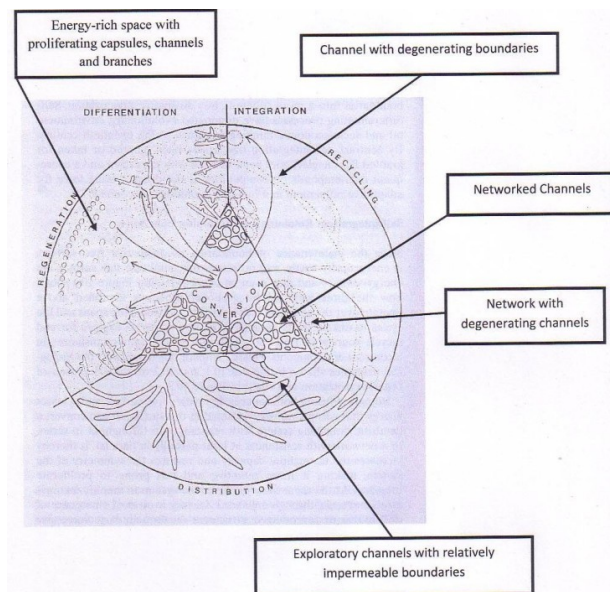


Fig.1 The interplay between boundary-proliferating ('differentiation') and boundary-condensing ('integration') processes in energy-rich (stippled) and energy-restricted circumstances. This interplay enables energy to be assimilated (allowing regeneration and proliferation of boundaries), conserved (by conversion of boundaries into relatively impermeable form), explored for (through internal distribution of energy) and recycled (via redistribution/reconfiguration of boundaries) in spatial capsules, channels, branches and networks of life forms in dynamic attunement with their natural neighbourhood. Thin lines indicate relatively more permeable boundaries, thick lines relatively impermeable boundaries and dotted lines degenerating boundaries[6].

The ecological and evolutionary sustainability of natural life forms, from the cells and tissues in a human body to the trees in a forest correspondingly depend upon close harmonization with (as distinct from unilateral adaptation to)

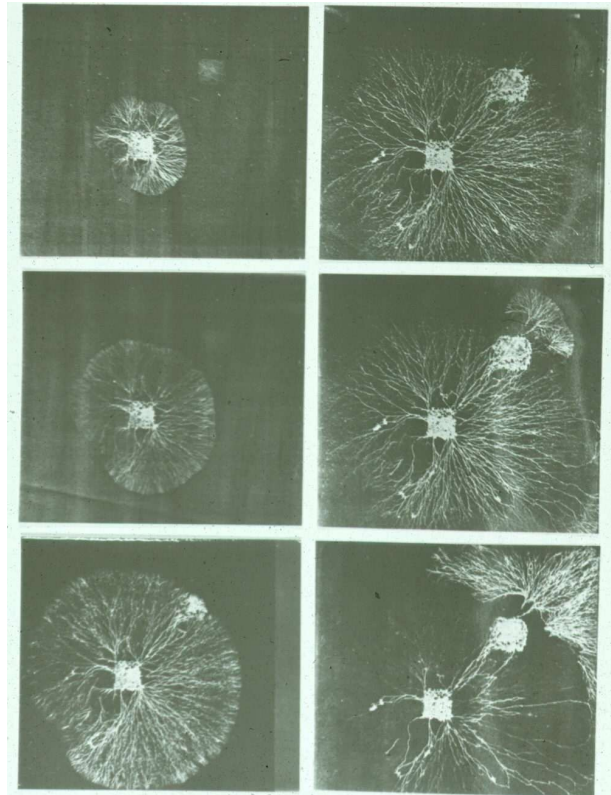


Fig.2 ‘Fungal Foraging’[6,16]. The mycelium of the wood-decaying fungus, *Hypoholoma fasciculare*, finds an ‘oasis in a desert’, by fluid-dynamically spreading and narrowing its energetic focus. The fungus has been inoculated into a tray full of soil on a block of wood (‘starter’ food source), with an uncolonized wood block (‘bait’ food source) placed some distance away from it. Distinct stages are shown in the radial spreading of the fungal colony from the inoculated wood block, followed by the redistribution and directional focusing of its energy following upon contact with the bait. As indicated in Fig.2, similar fluid dynamic patterns of gathering in, conservation of, exploration for and redistribution of energy supplies within variably connective channels and capsules of receptive space are found throughout the living world, from subcellular to ecosystem scales of organization.

the diversity, complementary nature and changeability of all within their neighbourhood, to which they themselves contribute. When energy supplies become scarce, sustainable living systems pool and redistribute internal resources within integrated structures and survival capsules - they do not compete to proliferate faster on the dwindling supplies than their neighbours. When supplies are abundant they proliferate and differentiate. Moreover, as is beautifully illustrated by the exploratory patterns of some kinds of fungi, this ability to attune their capacity to differentiate and integrate activity in dynamic relationship with energy availability allows life forms to locate and sustain supplies in heterogeneous habitats with extraordinary efficiency. As illustrated in Fig.2, they do this through a combination of all - round exploration and directional focus.

Sustainability, not supremacy, is therefore the path of evolutionary and ecological continuity. Natural energy flow is variably fluid, circulatory and redistributive along pressure gradients from higher concentration (relative 'abundance') to lower concentration (relative 'scarcity'), as illustrated, for example by atmospheric and ocean currents. The primary need for all life forms is not to seek competitive advantage through the unilateral accumulation of energy 'wealth' at the expense of their neighbourhood, but to sustain themselves and their offspring as variable channels for natural energy flow. They are more like members of a relay team than a set of autonomous individuals striving to be first past the post. To succeed in this they have to be open to the energetic influence of their neighbourhood at the same time as sustaining the distinctiveness - but not discreteness (or separateness) - of their inner worlds from their outer worlds through their dynamic boundaries.

Any ecological or evolutionary or management model that treats an individual or group as a discrete, autonomous object or subject with the set objective of promulgating and preserving its self at all costs as sole survivor of a war of attrition is therefore partial and unsustainable in a changeable world of natural energy flow. Unfortunately, just such models are implicit in the objectivistic framing of natural energy flow that continues to underpin our strategic planning for a desirable future and perceptions of what it means to be sustainable. We confuse sustainability with self-preservation, just as Darwin[8] did when describing 'natural selection' as the preservation of favoured races in the struggle for life. Why?

4 Unsustainable Logic: Self-Dislocation From Natural Neighbourhood

Notions of adversarial 'competition' and coercive 'co-operation', which respectively underlie individualistic 'capitalism' and collectivistic 'socialism', are predicated upon definitive logic that is incompatible with the cumulative energetic transformation of an evolving system[2]. It is presupposed that individual or group

entities can be defined independently from their spatial context and correspondingly that their 'future' can be fully defined by present or 'initial conditions'. As recognized by Bateson[17], this narrows the focus of perception and purpose at the outset of enquiry into nature instead of in the process of discovery (cf. Fig.2) and can give rise to the familiar idea that undesirable present 'means' can be justified by desirable future 'ends'.

Human beings may be cognitively and culturally predisposed to make this presupposition through a combination of our inter-related capacities for categorization, sociality, abstract thought, tool and language use and awareness of mortality[12-14,18]. On the other hand, the imagination that comes alongside these capacities offers the creative potential to escape the restrictions imposed by purposive abstract objectivity through what is actually the more comprehensive worldview of natural inclusionality[2-3,12].

As terrestrial, omnivorous, bipedal primates unable to digest cellulose but equipped with binocular vision and opposable thumbs that enable us to catch and grasp, we are predisposed to view the geometry of our natural neighborhood in an overly definitive way. We are prone to see the world in terms of what it can do for us and to us as detached observers or abstracted 'exhabitants', not how we are inextricably involved in it as natural inhabitants. We perceive 'boundaries' as the limits of definable 'objects' and 'space' as 'nothing' - a gap or absence outside and between these objects[1].

As discussed earlier, this perception of space and boundaries as definitively discontinuous is incompatible with the comprehension of continuity and change[2-3,19]. If two adjacent locations in space and/or time are distinguished by a boundary, which one does the boundary belong to? If it belongs to both of them, how can the mutual exclusivity of definitive logic be satisfied, and where do both cease to be both and become either one or the other? If it belongs to neither, then where does one location end and the other begin and what really comes between them? In the case of a curved boundary, does it belong to whatever lies within it or to whatever lies without it? If two distinct locations are both contained within a larger location, are they mutually exclusive or co-existent? Upon such dilemmas rests the whole gamut of alternative propositional (either/or) and dialectical/transcendental logics (both/and in mutual opposition) that have been in conflict for millennia and continue to be so[20]. So too do the 'holons' - as 'Janus-faced' entities combining individual and collective aspects, and 'holarchies' - as nested arrays of holons, of Koestler[21] in his 'Open Hierarchical Systems Theory'[22-23].

That it is nonetheless possible to avoid this perception is, however, evident from the indigenous cultures that sustain a much stronger sense of inclusion in Nature, aided by the preservation of oral, aural and nomadic traditions [24-25].

According to Walker[26], “Cross-cultural views of the self define individuality in terms of boundaries, locus of control and inclusiveness versus exclusiveness, or that which is intrinsic versus that which is extrinsic to the self [27-28]. Cultures that emphasize firm boundaries and high personal control tend to view the self as exclusionary or ‘self contained’. Fluid boundary, strong field control cultures, view the self as “ensembled,” meaning that the self is inclusive of other individuals. While ‘self contained’ individualism is indigenous to the United States and to the European countries from which its dominant ethnic groups draw their roots, ‘ensembled’ individualism is far more prevalent as a percentage of all known cultures[29]. Ensembled individualism is also indigenous to Aboriginal, Native American, Senoi and other cultures that are widely known to use dreams for social purposes.”

The perception of completely definable objects separated by intervals of space as ‘gaps of nothingness’ sets the scene for the hard line logic of abstract rationality to become established in the foundations of our mathematical, scientific, theological, linguistic, governmental and economic endeavors. It also profoundly affects our perceptions of ‘self’ and ‘self-interest’. The definitive supposition that one thing is not another thing, and, specifically, that ‘one self cannot be another self’ leads to what C.S. Lewis[30] called ‘the philosophy of Hell’, in which ‘to be means to be in competition’.

It is easy to see that this detached perception of nature and human nature in unnatural opposition could lead to profound human conflict and jealous possessiveness. With the continuous presence of space throughout and beyond all form erased from consideration, ‘subjective self’ and ‘objective other’ are brought into fear-full confrontation. Priorities are inverted from seeking sustainable relationship with others in a natural ‘communion of diversity’, to seeking cancerous dominion over other as the only certain route to ‘self-preservation’[25]. Sustaining ‘Ego’ becomes the focus of attention at the expense of the natural neighbourhood upon which individual self-identity actually depends to sustain itself. Love and trust of others break down into xenophobia and avarice.

Can this abstraction actually be intellectually justified as a means of representation consistent with sensory experience (i.e. evidence) and that makes consistent sense? In a word, no, it cannot, because energy/matter cannot physically be cut away from space[2,18,31-32].

Nonetheless, the dissociation of matter from space is embedded in the numerical and geometrical foundations of classical and modern mathematics. Here it may be recalled that Euclidean geometry is the abstract geometry of zero-dimensional (size-less) numerical points, one-dimensional (breadth-less) lines, two-dimensional (depthless) planes and three-dimensional solids (self-contained volumes). Its figures are used to represent definitive tangible structure and yet

can only actually represent the intangible presence in the core of tangible form because it is impossible to reach zero without removing the tangible presence. The same applies to the so-called ‘non-Euclidean’, Riemannian and Lobachevskian geometries of curved surfaces.

The scientifically inconvenient truth is hence that abstract Euclidian and non-Euclidean points, lines and planes/curved surfaces can consist only of intangible presence, not tangible presence! By the same token, it is impossible to drive or rotate a solid body from or around a solid fixed centre. The central ‘still’ point, axis or plane of symmetry of any bodily form can only consist of intangible presence, with correspondingly zero pressure. In effect, conventional mathematics and its discontinuous underpinning logic thereby treat ‘1’, as a ‘unit of tangible presence’, as if it is ‘0’, a vanishing point of intangible presence. They literally attempt to construct ‘one thing from nothing’ and then to sum an infinite number of these one things up into an infinite ‘whole’ as a ‘one’ that is also ‘many’, whilst discounting the very presence that truly is infinite, at all scales.

This difficulty can only be resolved realistically by accepting that in Nature, tangible and intangible presences are distinct but mutually inclusive. This is the point recognized by the fluid geometry of natural inclusionality. Here, space and boundaries are regarded as mutually inclusive sources of continuity and dynamic distinction with variable connectivity, not mutually exclusive sources of discontinuity and discrete definition, as in Euclidean and non-Euclidean geometries. So far, the only mathematical formulation explicitly to accept and incorporate this natural inclusion of non-local space in and throughout local figural form is the ‘transfigural mathematics’ introduced in 1985 by Lere Shakunle[32-34].

Natural inclusionality effectively transforms the fixed frameworks of Euclidean and non-Euclidean geometries into fluid framings of omnipresent, non-local intangible space everywhere, within (intra-), throughout (trans-), between (inter-) and beyond (extra-) local tangible energetic form[32]. This opens the possibility of a dynamic, co-creative, mutually inclusive relationship between internally and externally situated non-resistive (and hence receptive) intangible spatial presence and locally situated, tangible energetic presence.

5 Variable Connectivity: The Sustainable Self-Cultivation of Life

All that may therefore be needed to unlock our imagination and the world of real, live organisms and communities from the unnatural confinement imposed by abstract rationality is the simple understanding that space cannot be cut, occupied, confined or excluded. Space is a continuous presence throughout and beyond the boundaries of natural figures. By the same token, these boundaries are energetic interfacing between inner and outer realms, not fixed limits. This simple move from regarding space and boundaries as sources of discontinuity and

discrete definition to sources of continuity and dynamic distinction is the ecological and evolutionary point of departure of ‘natural inclusionality’ from objective rationality.

The underlying logic of natural inclusionality can be described as ‘the understanding of all form as flow-form, an energetic configuration of space throughout figure and figure in space’, such that space, as a receptive (non-resistive) presence, is not assumed to be discontinuous (i.e. to stop at discrete boundary limits)[12,26]. Correspondingly, we can recognize the impossibility of defining or measuring anything in absolute numerical terms anywhere, because all form has both a ‘figural’, energetic inner-outer interfacing or dynamic boundary, which makes it distinct, and a ‘transfigural’ (this term was first conceived by Lere Shakunle in 1985) - ‘through the figure’ - spatial reach that cannot be sliced or limited.

The continuous space throughout and beyond the figure pools it within the co-creative, influential neighbourhood of all others: local ‘self’ as an ‘including middle’ finds identity in its non-local neighbourhood as neighbourhood finds identity through its local ‘self’. Without spatial continuity, figures are rendered into lifeless bodies, integral or fractional numbers and idealized geometric points, lines and solids. With space included, we can escape the confinement and inconsistencies of the ‘excluded middle’, discrete boundary logic of ‘one opposed to other’ that has held human imagination to ransom for millennia. This enables us to move on to a more natural and comprehensive form of reasoning in the fluid boundary logic of each in the other’s mutual influence. The real meanings of ‘zero’ and ‘infinity’ as qualities of space and sources of creativity, not abstract quantities of material, are brought into our natural accounting systems, not excluded by abstract definition.

The following simple exercise might help illustrate the difference between the hard-line, space-cutting view of discontinuous models and fluid-line understanding of natural inclusionality. Draw an outline of two figures using a dotted line on a plain sheet of paper. The ‘paper’ infinitely stretched would represent what in the transfigural geometry developed by Lere Shakunle is called ‘Omni-space’[32,34]. The space within each figure represents ‘Intra-Space’, the space between figures ‘Inter-space’, the space beyond the figures ‘Extra-space’ and the space transcending the figures’ permeable and dynamic boundaries ‘Trans-Space’. You can see how the continuous non-local space everywhere (omni-space’) is locally configured into distinctive, but not discrete regions. In the way that you have drawn them, the figures are not contiguous (connected), and so their ‘intra-spaces’ can only communicate through the ‘inter-space’ and ‘trans-space’ between and permeating their boundaries as energetic interfacings and restraining influences (not restrictive material definitions or external forces - see later). Nonetheless, they

inhabit the same limitless pool of omni-space everywhere. If you were now to draw the figures closer together, so that their boundaries first connect and then coalesce at one or more points, their intra-space now becomes continuous (cf. Fig.3). On the other hand, if you were to take a pair of scissors and cut around the dotted lines, the figures will drop out of their spatial context as discontinuous individual entities. This ‘dropping out’ of context is what discontinuous models of reality effectively do - they treat boundaries as cut-out zones between discrete inner realms and outer realms, instead of dynamic relational interfacing through which these realms remain continuous through trans-space.

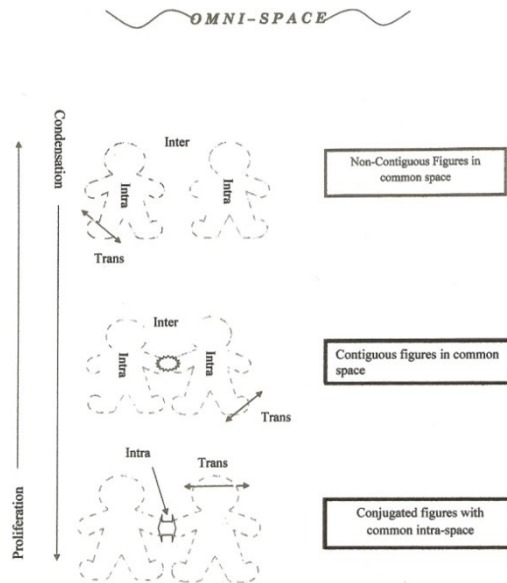


Fig.3 Distinct but not discrete figures of space in space (redrawn by Philip Tattersall from original pencil sketch by Alan Rayner, 2010).

Fig.3 illustrates the dynamic relationships between figural flow-forms as energetic configurations of space throughout figure and figure in space. It also serves to distinguish the natural inclusional dynamic relationship between distinct but not discrete flow-forms both from reductive schemas that cut off inner from outer spatial realms and from connective and holistic schemas where individual dynamic locality is eschewed from a seamless, purely figural whole or ‘unity’. Since the cartoons can only represent an instantaneous ‘slice’ through the figures, the dotted lines shouldn’t be taken to represent ‘sieves’ but more the seething ‘fluid mosaic’ that constitutes real biological membranes. A very simple example of what is represented in the cartoon can also be seen between surface-tense droplets

of water condensing on a surface. As they expand and come into proximity their tensely curved inner-outer interfacing first touch and then coalesce in a visible rush as each flows reciprocally into the other and the tension of their boundaries is released.

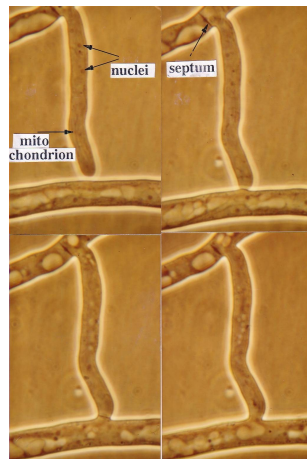


Fig.4 Stages (from top left clockwise) in fusion between the protoplasm-filled cellular tubes (hyphae) within the mycelium of the basidiomycete fungus, *Phanerochaete velutina*. The tubes are internally partitioned into distinct compartments by septa, which have a door-like pore in their middle. As fusion occurs (third picture in the sequence) the cell walls and membranes around initially distinct tubes coalesce, so that their intracellular cytoplasm, which in its turn contains membrane bound organelles (nuclei and mitochondria) becomes continuous. A visible recoil can occur in the receptive hypha when the tubes coalesce. (Photographed by Dr A.M. Ainsworth).

A living illustration of the process of figural boundaries coming into proximity, contiguity and conjugation occurs during the process of hyphal fusion that is found in many fungi[16] and is shown in Fig.4.

Here some fundamental differences between rationalistic and natural inclusion-al perceptions of connectivity and continuity emerge:

(1). In rationalistic thought, continuity is equated with ‘connectedness’ because space is regarded as void, a source of discontinuity or disruptive gap between and around ‘things’ as discrete objects. Hence the only way of deriving continuity in this ‘whole way of thinking’, is either by totally excluding space and boundaries from form as a continuous line or network of width-less threads, or by totally conflating space with form in a seamless [distinction-less] whole. Such exclusion or conflation is neither consistent with evidence/experience nor does it

make consistent sense.

(2). In natural inclusional thought, space is a continuous omnipresence that cannot be cut, occupied, confined or excluded, and form is dynamically continuous through its energetic inclusion of space throughout figure and figure in space. Distinction and difference are hence accommodated in a natural fluid continuum, without contradiction. Local identity is recognised as a dynamic inclusion of non-local space in which all forms are pooled together (but not merged into complete unity) in natural communion as flow-forms.

(3). Correspondingly, the treatment of continuity by objective rationality as the same as connectedness - as exemplified in conventional calculus, where continuity is approximated by connecting infinitesimal discontinuous units - is an idealized abstraction that is physically impossible. The very idea of complete 'whole units' existing anywhere, at any scale in Nature as an energetically open, fluid system does not make sense. The fluidly variable connectivity of natural inclusionality arises from the coming together (contiguity/inter-connectivity), fusion (confluence/intra-connectivity) and dissociation (individuation/differentiation) of energetic paths, corridors or channels of included space in labyrinthine branching systems and networks (i.e. as shown in Fig. 2), not the 'ties that bind all into a web of one'[1,31,35].

6 Flow-Networking

The space-including processes of regeneration, degeneration, differentiation and integration illustrated in Figs 1-4 are very different from the purely tangible connectedness of modern network theory. They inform us about how energy is assimilated, located, conserved and redistributed in real-world sustainable systems, as distinct from abstract mathematical models. This is the understanding that I suggest we need to incorporate into systems science. As we do this, there are a number of principles that we need to remember.

Rather than being formed by stringing together a given set of initially independent entities, flow-networks grow into place through a combination of self-differentiating (boundary-maximizing) and self-integrating (boundary-minimizing) processes that configure and reconfigure space in dynamic correspondence with energy availability. For example, fungal mycelia form when a spore germinates by first swelling symmetrically as it takes in water and nutrients across its bounding cell wall and membrane. The resulting structure then becomes polarized, hence breaking spherical symmetry and increasing surface area to volume ratio, through the emergence of a germ-tube or 'hypha' with a parabolic growing tip. As this tube elongates, its growth accelerates exponentially, as the absorptive surface increases, before attaining a more or less constant rate of extension, whence branches begin to emerge, each with their own parabolic growing tips. A den-

dritic (tree-like) system of hyphal branches develops, which radiates out in all directions. Eventually, in many fungi, as resources are depleted by the growing system, some of the branches begin to fuse or anastomose with one another, so converting the inner part of the system into a network of labyrinthine channels (as in Fig.4). During this process, the branches open up their external boundaries to one another, so that the inter-space initially between them becomes the continuum of intra-space within them. In other words, they ‘let go’ of their individuated self-identity ‘agenda’ in the process of coalescing by self-integration (cf. Fig.2). Within the integrated system, the branches do not disappear, but retain their form as connective channels of intra-space. The nodes in this system are the places from which the branches originally arose, rather than the loci of initially discrete entities. The branch-identities are the connective channels in the system, not the ‘knots’ or local centres through which network transactions are administratively controlled. At no stage in the evolution of the system have these identities been fully dislocated from one another or the limitless pool of common space in which they are immersed and of which they are dynamic inclusions.

By growing into place, these dynamic systems exhibit indeterminacy, the potential for indefinite expansion and transformation within boundaries that vary in their deformability, permeability and connectivity depending on contextual circumstances. This contrasts with the determinacy assumed by many to apply to creatures like our individual selves, sentenced to death within a fixed frame of bodily space and time and so bustling through life as if there were no place else to care for, notwithstanding the continuum of our social space.

Such indeterminacy brings scope for continual improvisation, discovery and learning through co-creative evolutionary play that is not fixed on a pre-determined course, but eases its own passage through a process of autocatalytic flow in which the flow of current lowers resistance to subsequent flow: sheep, wildebeest, ants and humans all exhibit this phenomenon as they create paths by following in one another’s wake[6]. Some fungal mycelia making their way through ancient forest in this fashion are thought to cover up to square kilometres of ground and to be thousands of years old.

By connecting their internal space in parallel rather than purely in series (as applies to dendritic systems, lacking anastomoses/cross links), flow-form networks greatly increase their conductivity and consequent capacity to store (i.e. ‘memorize’) and supply power at or to localities on their boundaries (cf Figs 1, 3). In fungi, this increased capacity is what allows mycelial systems literally to ‘mushroom’ as well as to produce survival structures such as sclerotia (of which ‘ergots’ are a well known example) and rapidly extending cable-like aggregations - known as ‘rhizomorphs’ because of their root-like appearance and growth. Mycelial systems that lack or lose the ability to form anastomoses are prone to

become dysfunctional and degenerate, proliferating numerous branches from local nodal sites in a way that looks very similar to some unrealistic ‘maps’ that have been made of the Internet using purely abstractive analytical techniques.

Local, well connected centers in flow-form networks drain resources from the system, and inhibit its expansion. In fungi, fruit bodies and storage structures may form at such centers. In human organizations they have the potential to develop into exploitative growths and megalithic power structures.

Degenerative processes in flow-form networks are vital as a means of preventing retention of power by core components of the system. For example, ‘fairy rings’, consisting of an annulus of spreading mycelium, result from the degeneration of the colony centre and release of its resources to supply the growing margin. In the absence of such degeneration, expansion of the system stalls. Death is vital to the possibility of continuing life: it feeds life and opens up new possibilities for reconfiguration - it does not annihilate life in the way that the rationalistic view of space as an absence of presence may lead us to believe.

The ability of flow-form networks to differentiate, integrate and degenerate, by varying the dynamic properties of their boundaries in tune with their circumstances and avoiding the wastage implicit in rationalistic ‘cost-cutting’, allows them to produce extraordinarily efficient organizations in highly heterogeneous situations. In fungi inhabiting the forest floor, for example, this ability allows them to make connections between local sources of nutrients in decaying wood, leaf litter and roots, to form an underground communicative infrastructure, which brings the lives and deaths of the trees into a common circulation .

So, altogether, these living flow networks are far more sensitively attuned to the ever-reconfiguring space that their channels embody, than the inflexible mesh-work entrapments our current abstractions represent. How do these principles translate into management praxis? I have just two general suggestions:

(1). Being alive to any life-form’s unique situation, the way it attunes with its neighbourhood, the complex relationships that such attunement entails, and the ease with which these relationships can be destroyed by insensitive intervention.

(2). Value one’s own learning experience, be prepared to share this with others and value others’ unique experience, rather than simply following or desiring some ‘one size fits all’ doctrine, fad or short term ‘fix’.

I have the feeling that these suggestions might sound rather obvious and lacking any absolute, clear, fixed, authoritarian direction. They might seem like not much more than we might gather about life’s patterns and uncertainties from our everyday experience as relational human beings - good neighbours using all our sentient faculties. I do hope so!

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