BOUNDARYLESSNESS:
INTRODUCING A SYSTEMS HEURISTIC FOR CONCEPTUALIZING COMPLEXITY

Beth Dempster, University of Waterloo Waterloo, Ontario – April 13, 2002
Prepared for Toward a Taxonomy or Boundaries, Matfield Green, Kansas, June 2002

Imagine a deep, thick west-coast temperate rainforest. Massive tree-trunks reach upward; branches interconnect in a three-dimensional weave that blurs the distinctions among individuals at the canopy level. Lush green undergrowth covers the forest floor. Filtered sunlight, caught by broad leaves, pumps surfeit water. Rotten logs provide a vertical head-start to species that can accommodate the acidity and hiding places for a multitude of small mammals, amphibians, bugs, worms and other creatures. The deep silence belies a frenzy of activity. Sometimes – if I'm quiet – I imagine I can hear trees growing and soil-microorganisms moving about. A fascinating, vibrant, complex ecosystem…

Yet the complexity only *begins* with such a biophysical description. Growing up in British Columbia – with a resource-based economy reliant on forestry – the economic and social importance of forests also became familiar. Integrated into the forest ecosystem, then, are loggers, silviculturalists, researchers and buyers; the clean fresh smell of just-cut lumber; the fine grain of old-growth smoothed under a carpenter's hand; the steaming pile of meat and potatoes served as Sunday dinner in a small town; the barren stumps and slag piles of a clear cut perceived as a blight, a new beginning or a means for providing that Sunday dinner, depending on the position and background – and species – of the viewer. The complexity, interconnections and interdependencies among the ecological, social, economic, ethical and other aspects seem to defy understanding.

Conceptualizing this situation in a manner conducive to manifesting sustainability – of ecosystems, economies, cultures and people – continues to be a significant and increasingly important challenge. While completing an undergraduate degree in forestry and wrestling with a small corner of this challenge – understanding the biophysical sustainability of forest ecosystems – I found appropriate concepts and heuristics to be lacking. Ecologically I learned about large-scale 'experiments' estimating nutrient and hydrological inputs and outputs over entire natural and harvested watersheds. Biologically, I learned about the requirements of different species for soil moisture, soil nutrients and shade tolerance. Economically I learned about non-market contingent valuation techniques as a means to 'value' the invaluable. Ethically I debated the challenges and implications of stretching the boundaries of moral communities beyond humans. This diversity of concepts and ideas provided valuable understanding, yet they relied on categorization, reduction and quantification. Complexity was simplified by isolating parts and drawing boundaries; by making distinctions: forest/non-forest, in/out, good/bad. While useful, these notions and requirements fit uncomfortably with my experience.

In particular, my search for concepts that would enable the characterization of ecosystems without requiring boundary delineation was unsuccessful. My response – through the naive intentions and desperate creativity of a 4th year student finishing her undergraduate thesis – was to invent a word and the subsequent description to occupy the void: *sympoiesis* (Dempster 1995). The term was developed from the Greek for *collectively-producing* and was chosen as a contrast to *autopoiesis* (Maturana and Varela 1980, Varela *et al*. 1974, Maturana 1980a, 1980b). In brief, sympoietic

systems are characterized by complex interactions among components and relations that recursively produce and maintain a self-similar, dynamic organization of evolving, interdependent complexity that is distinguishable as some sort of 'whole' or entity, yet has neither temporal nor spatial boundaries. Rather than maintaining their 'wholeness' through the delineation of boundaries, it is maintained by dynamic interdependencies and an interactive, balancing tension among components, processes and influences.

For many, the most contentious aspect of sympoiesis is the notion of boundarylessness. People point to the obvious ***existence*** of boundaries – including skin, bark, borders and cultural norms – to indicate the problem. I concede to the importance of questions about what a 'boundary' is, and about how they are characterized. However – regardless of how firm, fuzzy, permeable, variable, arbitrary, conceptual, useful or otherwise boundaries are taken to be – I resist statements of their '***existence***'. I speculate that such emphasis arises from our over-riding dependence on the visual and physical and on categorization, 'bounding' and reduction as means for understanding and interacting with that-which exists, especially through conventional scientific and management methods. Despite arguments against the notion of boundaryless systems, then, I maintain an interest in considering how to conceptualize 'systems' *without* boundaries – although as an *alternative to*, rather than replacement for, standard approaches.

The invitation leading to this paper offered the rare opportunity to be intellectually daring, possibly even indefensible – to go beyond the boundaries, so to speak. While greatly appreciating such an opportunity, it has seemed important for me to present the concepts I have/am developing – even though I consider them to be quite defensible (although perhaps contentious). Since the concepts are original and relatively new they still require introduction and explanation more than expansion. Rather than respond to the myriad fascinating questions put forward, or discuss the notion of 'boundary' per se, I describe a heuristic to aid conceptualization of boundarylessness. The ideas and theories presented build on notions of complex self-organizing, self-producing systems, synthesizing them in a unique manner. I have tried to be brief, but typically find it essential to present the whole package in order to give an adequate explanation of the concepts. Although much of the discussion does not focus on boundaries, the fundamental underlying motivation is the potential to conceptualize boundarylessness in a somewhat methodical manner. My intention is to explain the heuristics in sufficient detail for the reader to consider their application in areas with which the reader is familiar, using a variety of examples to facilitate understanding of the possibilities.

I begin the paper by placing myself on an ontological-epistemological map, which leads into discussion of systems and boundaries, both of which I take to be heuristics. Since the concept sympoiesis arose from a desire to relinquish boundaries, I outline some arguments against boundaries, although taking care to indicate that they also have value. I then describe the notions of autopoiesis and sympoiesis, using examples for illustration. The essential reason for building the theoretical platform is that conceptualizing phenomena according to these heuristics offers opportunities for understanding situations without the need to delineate boundaries. The brief examples are intended to be little more than tantalizing possibilities. They are followed by a brief description of self-organization, which offers a possible means for identifying boundaryless systems.

Although the poietic systems heuristics offer some potential for exploring self-reflexive epistemological implications of research and inquiry or perception and conception, I spend little space on these ideas, emphasizing instead a more solid understanding of the original conception of sympoiesis – a concept offering at least one mean for understanding or at least conceptualizing boundarylessness.

reality…

> It still remains a scandal to philosophy… that the existence of things outside of us… must be accepted merely on faith, and that, if anyone thinks good to doubt their existence, we are unable to counter his doubts by any satisfactory proof
> (Kant *Critique of Pure Reason*, preface to 2nd ed. [1958] in Pojman 1993).

> There is no single reality, but rather multiple realities, and what is represented depends on one's position in the field of negotiation… It is about an ongoing process of negotiating reality (Bird 1987: 258).

Entering a philosophical debate about reality is not the intent of this paper, yet a statement and brief explanation of my position seems essential. I consider myself to be an ontological agnostic – generally unconvinced about the certain existence of reality or the certain lack thereof. I have yet to find an irrefutable argument against Descartes' notion that reality could be only a dream or the more contemporary argument offered by the movie *Matrix*. I resist the skeptic only through *dis*belief that I could imagine a world as intricate as the one I seem to experience. In defending their respective arguments, I tend to find that realists bang on tables and constructivists rail against social codes, with neither fully attending to possible variations among these two 'realities'. In manifesting and experiencing daily life, it seems to me that a sliding scale – a continuum of sorts – presents the most acceptable approach. At one end is *physical reality*: I sit in chairs, bump into tables and occasionally worry, when backpacking, about people falling off cliffs. At the other end is *constructed reality*: I wonder about meaning, bump into social norms and occasionally worry, when writing, about falling into reification. Between and around these ends are varying expressions of *negotiated reality* – trade-offs between the problematic extremities. (For more detail and diagram, see Dempster 2001a). I take the term from Bird's reference (quoted above) to an "ongoing process of negotiating reality": While my reality might be constructed, there seem to be limitations to what I can construct – limitations that emerge at/from both ends of the continuum.

While I make these as ontological claims, I think it is also important to acknowledge their political implications. By drawing such distinctions, I imply that constructed realities such as social norms are more malleable and less solid or harmful to bump into.[1] Yet social norms can be as hard and immovable as solid rock. I point to the distinction in order to challenge the notion that just because particular social norms, habits or cultural customs *'are'* any particular way, they have to *stay* that way. I do not intend to deny the experience of those who bang into solid walls of custom, but to suggest that many of these walls need to – and can – change. I intentionally bump some social norms in order to try knocking them into something more equitable and encourage others to do so also. I seldom do such bumping with rocks – although, admittedly, even rocks change…

Fundamental to the process of negotiating reality is the need for, and use and development of, instruments and heuristics for conceptualizing those realities. We rely on tools and concepts to gather and organize our perceptions and sensations into understandings and ideas that enable our capacity to learn and to move successfully through our lives. Yet these tools and concepts

[1] I acknowledge discussion with my colleague Eric Tucs on these points.

themselves arise from our negotiated realities, which raises the question: How much do our heuristics, our interpretations of reality, and our realities influence the 'negotiation' each of us engages in? How much do the tools and schema we use for *conceptualizing* reality *determine* our 'reality'? There is need to attend to the weight and degree of – or at least acknowledge the presence of – the influences involved in developing our understanding. For example, how much does our reality have boundaries simply because we use boundaries to conceptualize it?

systems

One of the heuristics I find valuable for conceptualization – both theoretically and aesthetically – is the concept of 'system'. While some will argue that systems (just like boundaries) *exist*, I follow other systems-thinkers and consider them as heuristics:

> As any poet knows, *a system is a way of looking at the world*. The system is a point of view – natural for a poet, yet terrifying for a scientist! (Weinberg 1975: 52)

> A system is… an interaction between what is 'out there' and how we organize it 'in here'. 'System' denotes an interaction between the objective world and how it is looked at or thought about; it denotes a mode of perceptuo-cognito organization (Jordan 1969: 24-5).

Placing further emphasis on Jordan's use of perceptuo-cognitive and decreasing emphasis on Weinberg's use of sight, I consider a system to be a way of *conceptualizing* (rather than *looking at*) the world. While *per*ception *may* be a critical precursor to *con*ception, reference to anything as a "system" implies the latter.

The primary characteristic of the systems-heuristic is that perceptions and sensations are organized by drawing relationships among things to conceive them as *wholes* – as entities or sets of things that somehow belong together:

> A system is an assemblage of objects, principles, or facts, united by some form of regular interaction or interdependence into an organized whole (Roe *et al*. 1992: 27-8).

The notion of systems as 'wholes' leads to the definition of other system characteristics which are outlined in the following more explanatory definitions of system.

> A system, for example, may be defined as any entity, physical or conceptual, which is composed of interrelated parts. This is a widely held definition of a system; yet, it is so broad as to include virtually any interdependent set of activities or things… Every system has a structural configuration… performs certain functions… operates in a larger environment… requires certain inputs from this environment… can be thought of as moving through various states, following some definable process or set of procedures… [and] produces a set of outputs… [that] have a feedback effect on the system as a whole… While many disciplines choose to focus on one particular aspect of a system as a vehicle for analysis, a complete understanding of a given system can be derived only by taking cognizance of all these aspects… (Catanese and Steiss 1968: 173)

> This is about the limit of what we can say about every example of systems thinking. In summary, there will be:
> - an observer who gives an account of the world, or part of it, in systems terms;
> - his purpose in so doing; his definition of his system or systems;
> - the principle which makes them coherent entities;
> - the means and mechanism by which they tend to maintain their integrity;
> - their boundaries, inputs, outputs, and components;
> - their structure.
>
> Finally their behaviour may be described in terms of inputs and outputs or via state descriptions. (Checkland 1986: 102)

In grappling with trying to understand the 'sustainability' of west-coast rainforests, I found these characteristics and behaviours – the potential to conceptualize forests as systems – to be informative. In particular, as Catanese and Steiss note, the systems approach emphasizes the need to take into account all the various aspects of a system – a holistic approach. Yet I also found the approach to be inadequate. In particular, as exemplified by the quote from Checkland above, boundaries are typically taken as one of the fundamental characteristics or essential components of a system. Yet I balked at the instruction: 'draw a boundary'. Regardless of how temporary, permeable, or fuzzy the boundary was drawn or how carefully, conscientiously or reflexively the drawing was done – such an approach did not accommodate my experience of forests or my sense of the understanding required for their appropriate management. I subsequently turned to consider the possibility of relinquishing boundaries.

boundarylessness

> Distinction is the essence of boundaries. To illustrate, consider that a system may be defined without explicit attention to boundaries: A system may be conceptualized in terms of a set of interrelations among components and actors. However as soon as a system is conceived, so is its boundary. Simply by including one set of actors and components in one's understanding of "the system", others are excluded. There is 'system' and there is 'not-part-of-this-system'. There is a boundary. The boundary is the conceptual space where the distinction between system and not-system happens (Bunch 2001).

Boundaries are generally taken as necessary for making the distinction between system and environment. While definition of boundary as a "conceptual space" could provide another approach for alleviating some of my boundary-related concerns (noted below), I question the clarity – and the necessity – of the distinction articulated in this quote. System vs. not-system indicates a binary conceptualization of the world, which – although popular – is not the only one available. Janian logic, for example, has seven instead of two categories. Three of them – is, is not, is indeterminate – reflect a familiar 'western' phrase I remember learning a long time ago: yes, no, maybe so. Think of the primary colours red, blue and yellow or the gradation of a colour wheel, rather than black and white. Consider the difference between 'we' and 'us vs. them'. While the latter binary categorization sets up a conceptual (and also often cultural, racial, gender, etc.) boundary between two groups, "we" simply identifies a collective of individuals – a "system," if you will, but one that does not need to be defined by distinction against 'other':

> "We" does not require an opposing "they," "we" also denotes the relationship between "you" and "me." Once the term "we" is understood communicatively, differences can be respected as necessary to solidarity. Dissent, questioning, and disagreement no longer have to be seen as tearing us apart but instead can be viewed as characteristics of the bonds holding us together" (Dean 1996: 8).

One of my concerns regarding the use of boundaries, then, is their easy application toward the construction of binaries, which can be problematic by creating, for example, a false sense of certainty: With only two categories, one can be certain that anything *not* in one, *is* in the other: if not white, then black; if not right, then wrong. Even the addition of one more category increases the complexity and uncertainty: if not blue, then maybe red or maybe yellow; if not yes, then maybe no, but maybe maybe. Gradations tend to raise questions and perhaps contingencies: Does that seem blue to you? or kind-of greenish…? Well, probably not right now, but maybe later…?

A related concern is that the distinctions made with boundaries, especially binary distinctions, so often become categorically oppositional – with "boundary" enabling the opposition and leading to a territorial attitude. The focus shifts to: in/out, black/white, right/wrong; boundary maintenance becomes critical, boundary defence even more critical; differences gain central importance, and

relations become de-emphasized. In so many cases this seems to be mis-leading and potentially damaging.

> ...notice that the opposites of inside vs. outside didn't exist in themselves until we drew the boundary... It is the boundary line itself, in other words, which creates a pair of opposites. In short, to draw boundaries is to manufacture opposites. ...every boundary line is also a potential battle line, so that just to draw a boundary is to prepare oneself for conflict. Specifically, the conflict of the war of opposites, the agonizing fight of life against death, pleasure against pain, good against evil... The simple fact is that we live in a world of conflict and opposites because we live in a world of boundaries. Since every boundary line is also a battle line, here is the human predicament: the firmer one's boundaries, the more entrenched are one's battles...
> (K. Wilber 1985: 18-19)

This statement echoes some of my own concerns. Yet I also discern a glimmer of the challenge and paradox involved in relinquishing (or at least attempting to relinquish) boundaries – for the statement itself carries a hint of boundary/battle cry: *every* boundary line *is* a battle line.[2] Letting go of boundaries presents a continual and paradoxical challenge since – to at least some degree – any firm statement against boundaries sets a boundary. Relinquishing boundaries, then, does not mean arguing against them (only), but *also* offering other means for conceptualizing that-which-exists and maintaining some flexibility regarding when/how either one is applied. No-boundary-thinking seems to be a fundamentally different *type* of thinking than boundary-thinking. I believe it needs encouragement.

This raises questions about how entrenched the concept 'boundary' is to our way of thinking. I sense subtle influences here. It seems that boundaries are so fundamental to particular styles of thinking and ways of being that they are assumed – an ingrained influence on both our perception and our conception of that-which-exists. How many of us are programmed (predisposed?) to think: boundaries? How many of us are decidedly uncomfortable with (rather than just perplexed by or new to) the idea of boundarylessness? In addition, I sense that relying on a boundary to delineate the separation of system from environment promotes a tendency to disregard the environment as background even though it may be valid and constructive. The complexity of interactions, inter-relations and interdependencies that make up "the environment" are reduced to inputs and outputs or written off as insignificant and irrelevant rather than recognized as constitutive – and full of both uncertainties and possibilities. Drawing a boundary enables, not only reduction, but selective attention. The 'system' becomes the central focus, with all else comfortably designated as quantifiable flows in and out and all but excluded from consideration. By designating it as "the environment" it often seems to me that we give ourselves permission to discard everything beyond the boundary from concern and attention.

Admittedly, I do not *know* that boundaries – even fuzzy, permeable, temporary intermittent boundaries – have this effect. But I wonder. I wonder because examples of such restricted focus and release of attention seem commonplace: stand-density diagrams for managing forests; the enclave mentality in protected area management; territorial displays over cultures, race, or academic disciplines; the conventional 'scientific' approach to medicine; 'success' measured by income bracket. Each of these is facilitated by the presence of a 'boundary' to identify the subject of focus. Yet each of these examples points to concerns and behaviours many (now) consider problematic. Attempts to learn or create our way out of these situations can readily be found: greater park ecosystem conservation planning to incorporate factors outside park boundaries;

[2] I should note, however, that such a stance is not illustrative of Wilber's work. Rather, he emphasizes the value of "no-boundary thinking" in a very no-boundary thinking kind of way.

hybrid cultures, anti-racist rallies and interdisciplinary studies as more common activities; 'holistic' medicine to heal body, mind and spirit together; ads for cars or bank-loans that – while still suggesting the need for money – picture successful people relaxing by a lake, playing with their kids or driving through a thick forest…

Such a shift can be conceptualized in at least two ways: as indicative of expanding boundaries or of relinquishing boundaries. Since the former externalizes or refocuses rather than addresses the concerns, I apply my efforts to develop and understand the latter. Relinquishing boundaries, however, is not to denounce valid reasons, preferences or value in using them – sometimes in someplaces. The point is to consider the conceptualization of boundaryless systems as an *alternative*. As noted with respect to the quote from Wilber, to do anything else sets a boundary rather than relinquishing one.

As with systems, I take boundaries to be conceptual devices – heuristics for simplifying the conceptualization of a set of phenomena by encircling the 'whole' that is sensed to exist. They are valuable for making clear and precise distinctions and clear and precise system identifications. Given the concerns, there is also value in having other approaches for identifying and describing systems such as establishing distinctions by characterizing and comparing attributes or by drawing relations rather than drawing boundaries: you and me and whoever else comes along to join us, rather than you and me against the world.

> Note that a system is a whole thing, and although complex it has parts that are connected to each other in some way; thus smaller parts of systems can be identified, but it is the connection which makes it a system… (Chadwick 1966: 184)

It seems to me that the notion of 'system' is extraordinarily well suited for addressing the type of situations where boundary delineation is particularly problematic. For example, many entities or sets of phenomena – such as ecosystems, economic systems, and cultural systems – are quite comfortably and consistently referred to as 'systems' despite their lack of obvious boundaries. Reference to social, knowledge, transit, information, or management *systems*, is generally used to indicate their interactive, composite, relational nature as identifiable – and singular – entities; parts-in-relation that form a whole. In these cases, components are readily identified as 'belonging together' without enclosing them with boundaries. Rather than being an essential characteristic defining the very nature of 'system', it seems that boundaries are drawn to simplify the complex interconnected interactions that are readily recognized as 'systems'. Boundaries are attempts to accommodate our cultural and methodological preferences for contained, quantifiable, categorizable entities.

In the big, wild BC rainforest that I am familiar with, for example, the *components* might reasonably be defined by drawing boundaries to make system-environment distinctions (although mychorizzal fungi provide a bit of a challenge), but defining the *forest* in this manner seems inadequate. We draw boundaries to facilitate a particular style of scientific inquiry and of management, yet standing amongst the tall trunks and green undergrowth, the over-riding sense is not boundary, but relation and interaction. For me, it is the latter two qualities that characterize the very essence of 'system.' Insistence on boundaries seems to dampen the valuable potential for conceptualizing reality that 'systems' offers. There seems benefit in disconnecting *per*ception from *con*ception. To recognize the inclusion of complex entities such as forests as 'systems', I propose relinquishing the need for boundaries as defining characteristics, placing emphasis on components and, especially, on relations as a means of interconnecting parts to conceptualize 'wholes'.

In the case of complex systems, I propose the notion of sympoietic systems: complex, boundaryless, collectively-producing systems (Dempster 1995, 1998a), choosing the term in contrast to the concept of autopoietic systems – self-producing, composite systems that generate their own boundaries (Maturana and Varela 1980).

Theoretically, there are two basic ways in which the sympoietic system-heuristic can be described: as a contrast to autopoietic systems and as a type of self-organizing system. In an attempt to be somewhat comprehensive, I do both, hoping the subsequent brevity is not counter-productive. Further detail on the notions can be found in earlier work from which some of the following explanations have been summarized (Dempster 1998a, 1998b, 2000).

autopoietic and sympoietic systems

I begin with explanation of autopoiesis, noting that my explanation relies primarily on the earlier work of Maturana and Varela, including their original definition of autopoiesis, and on the work of others arising from it. All of these have a more biophysical basis, even when applied to social systems. Autopoiesis has also been applied to cognition and has contributed to radical constructivism (e.g. von Glasserfeld 2001) and conceptions of embodied knowledge (e.g. Varela *et al*. 1991, Maturana and Varela 1987) – valuable epistemological interpretations and theoretical directions, which I will not endeavour to cover here.

As another caution, I admit to being continually challenged by the process of negotiating reality and my own tendency toward reification. It will not take an especially perceptive reader to notice this difficulty in my explanations and examples – especially with respect to the distinction between systems-as-heuristic and systems-as-existing-realities. Whether the slippage evident in my writing reflects the way things *are*, the way I have *learned* them, or the way I *construct* them, is a question that remains – for me – continually outstanding.

To explain the heuristic autopoiesis, I begin by describing organisms as autopoietic systems.

We generally conceive organisms to be composed of smaller interacting parts such as cells and organs that work together through a variety of processes to create a whole entity: a living individual. The identity of any particular type of organism – tree, salamander, person or mychorizzal fungi – arises from relations that connect different parts and processes into specific arrangements – the pattern of their organization. A tree, for example, is identified as an organism in which roots are connected to leaves through trunk and branches as well as the processes of transpiration and photosynthesis. Somewhat different patterns of organization are recognizable in deciduous and evergreen trees, which have different types of leaf arrangements and which vary in transpiration and photosynthesis across seasons.

An organism survives and maintains itself through the exchange of material and energy with its environment. “Food” – which can be considered as inputs enabling continued survival of the organism, including possible changes such as growth and development – is defined by the organism and is monitored and restricted by a boundary. An organism will prevent inputs that would alter their parts and processes or their appropriate arrangement in a way that would dis-allow continued survival. The boundary – bark and leaf surface for example – is produced and maintained by the organism to establish it as separate from its environment.

To draw-out the autopoietic-theoretical aspects of this description, I relate definitions that originated in the work of Maturana and Varela (1980, Varela *et al*. 1974, Maturana 1980a, 1980b).

The *pattern of organization*[3] of a system refers to the relations among components that define a system as a specific type of system (e.g. living system, tree, car). The *structure* of a system refers to the actualization or manifestation of those relations and components to constitute an existing entity in a particular domain (e.g. physical manifestation of a specific individual tree or car in the physical domain).[4] Any pattern of organization can be manifest in many different structures. A somewhat simplistic analogy is to think about pattern of organization as an interactive dynamic blueprint, and structure as its interactive dynamic manifestation.

Distinguishing between these two aspects facilitates conceptualization of the following notions.

Organizational closure refers to the degree of self-containment a system has with respect to its pattern of organization. A system can be organizationally *open*, *closed* or *ajar*,[5] depending on whether its pattern of organization is completely determined by *external* sources (such as a car), completely determined by *internal* sources (such as an organism as described above), or primarily determined by internal sources but also influenced by external sources (such as an ecosystem as will be described below).

Structural coupling refers to the interdependencies that exist (or emerge) between a system and its environment in the domain in which they both exist. For example, food is a structural requirement for an organism (manifest in the physical domain) that is obtained from its (physical) environment. A system's need to obtain specific food from a specific environment reflects the structural coupling between them.

Differentiating among these concepts allows conceptualization of systems that can be simultaneously open and closed, in different, mutually interactive, ways: they can be *organizationally closed* but *structurally open*. For example, a living organism with a genetic 'program' determining its pattern of organization is closed to anything but 'programmed' changes to its pattern of organization. However, the organism processes structural inputs of energy and nutrients and is, consequently, structurally open. This distinction indicates the potential to differentiate between autonomy and independence: Systems may be autonomous in the sense that they produce their own organization, yet still be dependent on structural inputs from their environment.

Given these definitions, Maturana and Varela conceptualized autopoietic systems with two basic attributes. First, they are characterized by a continuing process of production in which the system has a pattern of organization that enables it to perpetuate itself by producing its own structural components from structural inputs and organizing the relations among these components in such a manner as to ensure the continuation of its own pattern of organization. Second, such a system produces its own boundaries as "surfaces of cleavage" that identify it as a composite unity separate from its environment. I refer to the process of production as *poiesis* and – rather than take it as relevant only to autopoiesis – I apply it to a more general class of systems that exhibit this continuing process of production, which includes sympoietic systems. Poiesis, then, refers to

---

[3] Maturana and Varela used the term "organization" to describe this concept. I follow Capra (1996) to avoid confusion with human organizations such as institutions.

[4] Note that this definition fits a vernacular understanding of structure, which typically refers to a physical entity – something present and 'real' – it does not match the definition applied in some disciplines. For example, in some cases, such as when contrasted to process, structure more closely represents what is here being termed pattern of organization.

[5] Maturana and Varela used the notions of open and closed – *ajar* is my own addition to recognize the different process in sympoietic systems.

'*self*'*-production* – continual production of the *same* system – whereas *re*production refers to production of *another* system; another structure with the same pattern of organization. Continued poiesis depends on a structure's ability to obtain requirements from, and respond suitably to, its environment.

Sympoietic systems differ from autopoietic systems, in that they are *organizationally ajar* and *boundaryless*. I illustrate by providing a sympoietic description of ecosystems.

We generally conceive of ecosystems as composed of interacting parts – organisms as well as geophysical elements such as soil and climatic factors – working together through a variety of processes to create a definable whole. Similar to organisms, the identity of any particular type of ecosystem arises from the composition of these parts and processes and their arrangement – the pattern of their organization – which we use to distinguish among forests, grasslands and wetlands, for example. Each of these different patterns of organization may be manifest in different structures. An eastern mixed-wood forest is different from a west-coast temperate rainforest; a short-grass prairie, different from a tall-grass prairie. Unlike organisms, however, ecosystems do not have the same kind of genetic 'program' determining their identity, nor do they have self-produced boundaries.

For example, although many would readily call the westcoast rainforest noted in the introduction a system, the boundaries are by no means apparent. Especially standing within, the sense is overwhelmingly of components and relations. Even flying over the forest, the only clearly discernible boundaries are shoreline and clear-cuts and, moving up the flanks of the taller mountains, the gradual transition into bare rock and snow. While these may be boundaries, they are not 'self' produced. For example, even the treeline is a result of biological as well as climatic factors. If the latter are included as part of the system producing the boundary, then the boundaries must be drawn to incorporate these components, which would include a greater spatial extent, moving the boundaries further out. Delineating boundaries for such a system, by choosing particular criteria to distinguish in and out, is one means for conceptualizing it. However:

> In principle an observer has the freedom to choose the system boundaries, he can decide which objects in the world he wants to take together. Of course he cannot decide whether his choice will be successful, this is a matter of experience (Dalenoort 1989: 301).

I suggest that an alternative, especially in those cases where the choices are problematic, is relinquishing boundaries. As noted earlier, the overwhelming impression in the forest is relation and interaction. Rather than produce boundaries to separate them from environments, ecosystems seamlessly integrate with their environments – to the degree that relating the concept of 'ecosystem' to three-dimensional physical space is problematic. Kimmins (1987: 27), for example, considers using the notion of "biogeocoenose" – a place-based concept – instead of 'ecosystem', to avoid reification.[6]

Admitting ecosystems as boundaryless, however, does not lead to the disquiet associated with 'anything goes'. Rather, ecosystems seem to offer a fine example of reality resisting: there appear to be patterns and identities – even if not definable boundaries – that require some degree of negotiation for conceptualization. The phenomena that are typically described as "ecosystems" are conceived as having recognizable patterns of organization and structures and to limit changes in these in a self-determined manner. I refer to such systems, as organizationally ajar – as systems

[6] This may, however, be an example of externalizing, rather than removing or addressing, the problem.

that allow, but restrict, changes to their patterns of organization. Rather than refuse inputs to prevent change in their pattern of organization, for example, ecosystems allow the introduction of new species, which may alter their identity considerably. However, they are not completely open, since inputs must be able to structurally couple in order to integrate into the system. For example, a plant species with a structure that cannot tolerate wet and shady conditions will not be integrated into a west-coast rainforest. A species that does have a structure able to successfully couple will be incorporated and has the potential to alter the forest's pattern of organization – even to the degree that a forest becomes a grassland, or vice versa…

These descriptions indicate – as noted earlier – continual challenge in considering 'systems' – including autopoietic and sympoietic systems – as heuristics rather than as existing entities. For example, I find it simple and straightforward to interpret organisms as autopoietic and ecosystems as sympoietic, but the reverse seems more difficult. The temptation to think that organisms *are* autopoietic and ecosystems *are* sympoietic is tantalizing. While this could illustrate reality resisting and establishing the need for negotiation, I think this more likely reflects that I and others have been educated/socialized to interpret most complex systems, including ecosystems, as having boundaries and therefore, as autopoietic. For example, education/enculturation in the fairly common 'harvesting' mentality of UBC Forestry – which has been the incubator for BC forest practice for many years – promotes interpretation of forest ecosystems as autopoietic. Silvicultural techniques are designed to enhance the 'life-cycle' of a forest by shortening developmental stages through planting and weed treatment. Stand density diagrams are used to plot expected growth, with the intention of planning various treatments (spacing, pruning, fertilization), across the 80-130 years required to create a marketable crop.

Dissatisfaction with the discrepancy between my experience and this autopoietic conceptualization led me to form the concept of sympoiesis. Further refinement of the concept has facilitated interpretation of ecosystems in a different manner, as described above. To enrich both description and subsequent understanding it is instructive to reflect on metaphors encouraging similar shifts in thinking. I find postmodern/poststructural contemplation fruitful in this regard, particularly Deleuze and Guattari's metaphorical use of "rhizome" – a decidedly sympoietic concept. To illustrate, I quote at length:

> In contrast to centred (even polycentric) systems with hierarchic modes of communication and pre-established paths, the RHIZOME is an acentred, non-hierarchical, non-signifying system without a general and without an organizing memory or central autonomon, defined solely by a circulation of states… [A rhizome] is not made of units but of dimensions, or rather of shifting directions. It has neither beginning nor end, but always a middle, through which it pushes and overflows… Such a multiplicity does not vary its dimensions without changing its own nature and metamorphosing itself. Unlike a structure defined by a set of points and positions, with binary relations between these points and bi-univocal relations between these positions, the rhizome is made only of lines: lines of segmentation and stratification as dimensions, but also lines of flight or of deterritorialization as the maximal dimension according to which, by following it, the multiplicity changes its nature and metamorphoses… (Deleuze and Guattari 1983: 47-48).
>
> Where a tree is a single vector aimed at a specific goal, the rhizome expands endlessly in any number of directions, without a centre… Its multiplicity is part of its nature, not its by-product (Mansfield 2000: 142-3).

In drawing attention to Deleuze and Guattari's differentiation between trees and rhizomes, Mansfield points to reasons that echo my own decision to continue developing the notion of sympoiesis:

> As with all metaphors that have become uncontested and obvious, the reasons for this usage [of tree as a predominant metaphor] are often seen as simple. Things grow and diversify the way trees do, we believe. But what assumptions and investments are preserved uninterrogated in this sort of metaphor? (Mansfield 2000: 141).

This is essentially the same question that I raised above regarding use of boundaries. Further, regarding the development of an alternative concept:

> This is no extravagant repudiation of the truth of the biological functioning of structures like the human body. Instead, what is being challenged is the simple assumption that things are to be understood as autonomous and separate, holding their truth in their coordinated internal structure. Rhizomatics rejects the idea that we can ever arrive resolutely at the advanced separation of things from one another which is the minimum starting point for the traditional representation of the world as the collocation of autonomous units (Mansfield 2000: 147).

Rather than claim the sympoietic heuristic as inappropriate or irrelevant to organisms, I wonder what insights might emerge from such application – even while finding it a challenge. As an example of such a possibility, Deleuze and Guattari describe the physical tracing of orchid to wasp and wasp to orchid, each shape molded to the other, with a subsequent mutual reliance for continued poiesis: "wasp and orchid thus make a rhizome" (Deleuze and Guattari 1983: 19). This conceptualization of the wasp-orchid system – as well as any other symbiotic relationship – expands the notion of organism into something more sympoietic.

Another example is to question the degree of organizational closure in organisms that have been genetically modified, or even in any domesticated or hybridized organism or those that have been fertilized or treated with pesticides or biological controls… A sympoietic interpretation of long straight cucumbers and large bananas would include social preferences as part of the system…

Regarding the identification and description of boundaryless sympoietic systems, I make a critical point. If a person considers a set of phenomena as a sympoietic system – and then draws a boundary around the phenomena/system for convenience or to establish a 'working definition' – *they are no longer interpreting the phenomena as a sympoietic system.* Conceptualizing something as sympoietic requires relinquishing boundaries – *with* boundaries it becomes a different kind of system. Boundarylessness cannot be described with recourse to boundary delineation as a means of making conceptualization more convenient or simpler. This raises the question, of course, about how we might identify or define a system, or speak of any set of phenomena as a whole or an entity, without delineating boundaries.

As noted above, distinctions can be made by drawing boundaries, by drawing comparisons or by drawing relationships. In drawing comparisons, it is necessary to have a means for characterizing autopoietic and sympoietic systems in order to identify and compare the various attributes of the phenomena observed.

characterizing autopoietic and sympoietic systems

Definition of the poietic system characteristics described above augmented by the boundary problematic, led to the conceptualization of sympoietic systems – as a contrast to autopoietic systems. Similarities and differences in the defining attributes of these two system types – poiesis, degree of organizational closure, and boundaries – lead to differences in characteristics and behaviours between the two system types, including different advantages and disadvantages (Table 1). Perhaps the most beneficial consequence of conceptualizing the distinction between the two system types is the ability to link the characteristics of each type together – to provide a theoretical

basis for grouping each set of characteristics. Although any set of phenomena interpreted through these heuristics will not unconditionally fit either set of characteristics, an interpretation that mixes 'opposite' characteristics (e.g. centralized control and adaptive) would raise questions regarding the appropriateness of the interpretation.

Table 1- Comparison of poietic system characteristics

AUTOPOIETIC SYSTEMS	SYMPOIETIC SYSTEMS
Defining Characteristics	
self-produced boundaries	lacking boundaries
organizationally closed	organizationally ajar
external structural coupling	internal and external structural coupling
Characteristic Tendencies	
autonomous units	complex, amorphous entities
central control	distributed control
'packaged,' same information	distributed, different information
reproduction by copy	amorphous reproduction
evolution between systems	evolution within system
growth/development oriented	evolutionary orientation
homeostatic balance	balance by dynamic tension
steady state	potentially dramatic, surprising change
finite temporal trajectories	potentially infinite temporal trajectories
predictable	unpredictable
Advantages/disadvantages	
efficient	adaptable, flexible
constrained, codified information	open to new and different information
require certainty	ok with surprise

From Dempster (1998).

The critical difference between autopoietic and sympoietic systems – related to the difference regarding boundaries – is their degree of organizational closure. Autopoietic systems are organizationally closed. They generate barriers to limit external interference, separating themselves from their environments in a self-determined manner. This allows them to maintain organizational closure by controlling inputs and outputs. The distinction between organization and structure makes it possible to illustrate that the autonomy of autopoietic systems is *not* equivalent to independence. These systems require structural exchange in order to maintain autopoiesis and will eventually become structurally coupled to specific environments, requiring specific structural inputs. Autopoietic systems, therefore, are homeostatic systems geared toward self maintenance and efficiency. Organizational closure enables them to keep out undesirable information while keeping essential information. This gives them the ability to build up complex information about their pattern of organization – a 'memory' or history of past interactions (e.g. in genes).[7] Since this

[7] Maturana and Varela suggest that information is not a relevant concept with respect to autopoiesis. They claim these systems must be understood in terms of their self-referentiality without information, which is an externally defined property. I believe this prevents recognition of system history and therefore argue for including information, cautioning against its reification.

organizational information is limited to what is contained in the system, however, autopoietic systems have a limited capacity for coping with uncertainty in their environment. Their ability to adapt by changing their pattern of organization, and consequently their structure, is restricted. Since environments continually change, autopoietic systems will eventually reach a point at which adaptation is no longer possible in both a developmental and an evolutionary sense.

In contrast, sympoietic systems are organizationally ajar. Lacking self-defined boundaries, sympoietic systems are open to a continual flux of organizationally relevant information, regulating it through internal structural coupling. This means information with the potential to influence their pattern of organization must be contained in a suitable structure in order to be incorporated into the system. As an example, new organizational information embodied in an exotic species will only be incorporated into an ecosystem if the exotic has a suitable structure – if it cannot find appropriate food, it will not survive. It is this dynamic, yet restricted, flux of information that allows the systems to be organizationally ajar. This allows them to capitalize on new information relevant to their pattern of organization as the very source of opportunities for adapting to change in their environment. Sympoietic systems evolve continuously, then, by adapting to changing conditions and by generating new ones. Historical and successional change in ecosystems are examples. In consequence, sympoietic systems are evolutionary and unpredictable with potentially infinite trajectories and the possibility for dramatic and surprising change. These are characteristics that reduce their efficiency – such continual change is not without cost. 'Stability' in a sympoietic system is a balance maintained by dynamic tension. The mechanism for 'equilibrium' is not homeostasis, but ongoing self-organization. These systems are generated and maintained through recursive interaction among many interacting global–local influences augmented by positive feedback as will be described in the section on self-organizing systems below.

In contrast to the centralized information of autopoietic systems, sympoietic systems carry information distributed among their components precluding the possibility for centralized control and limiting the potential for developing complex patterns of organization. Note, however, that the complex information in sympoietic systems is typically contained in autopoietic systems, which form the components of sympoietic systems. While the autopoietic systems depend on sympoietic systems for structural exchange (sympoietic systems effectively form the environment of autopoietic systems) sympoietic systems rely on autopoietic systems for the ability to build up complex patterns of organization and structures. Neither system is more important or independent since they are nested within each other. In addition, each system type has advantages and disadvantages, although the latter must be recognized as contextual judgements. For example, organizational closure is an advantage with respect to maintaining internal complexity and identity, but it is a disadvantage with respect to the ability for accommodating surprising environmental changes.

social examples

The foregoing descriptions of organisms and ecosystems fit readily with fairly conventional understandings. Yet as heuristics these system types have broader applicability, in particular, to socio-cultural phenomena, as well as to the interconnections among physical, biological, social, cultural and other phenomena. Table 2 lists some examples, including three that are discussed briefly below. These interpretations are not intended to be definitive descriptions, but rather food for thought.

A common critique that arises regarding such application is to question the legitimacy of applying heuristics and understanding relevant to conceptualizing biophysical phenomena in the socio-cultural domain. With respect to autopoiesis, for example, there has been considerable discussion regarding the suitability of such extension (e.g. Fleishaker 1992, Mingers 1995) with many arguing against application to social systems. Many others, however, have found the notion of autopoiesis useful and have applied it – and associated concepts – to a range of social situations and phenomena (e.g. Bednarz 1988, Luhmann 1989, 1990a 1990b, 1995, Fleishaker 1992, Kickert 1993, Mingers 1995). Rather than joining or reinforcing either position, I raise the reverse argument and question the validity of application in *both* cases. As aids to the conceptualization of complex phenomena, application of these systems-heuristics to social phenomena *and* biological phenomena is potentially useful, but also continually suspect. The possibility of conflating that-which-exists and that-which-is-conceptualized-as-existing is continually a concern. As noted near the beginning of this paper, the argument I find most plausible is that 'reality' is a negotiable understanding influenced by that very understanding – a self-referential process of interaction.

Table 2 – Examples of autopoietic and sympoietic conceptualizations

AUTOPOIETIC SYSTEMS	SYMPOIETIC SYSTEMS
tree	forest
bulb	rhizome
individual human	community
clique or group-think	open group
technical jargon	common language
expert driven task force	participatory process
conventional notion of power	Foucault's notion of power
modern self	postmodern self
normal science	post-normal science
'white' women's movement	differential form

Some have explored this self-referentiality through an epistemological application of autopoiesis – an interesting and important discussion that could offer fruitful exploration of the boundaries (and the dissolution of boundaries) between subject and object, researcher and researched by incorporating the notion of sympoiesis. While I have recently begun such exploration, I will not report on it here (see Dempster 2001c, 2002 and also Wolfe 1998, Rasch and Wolfe 2000).

In a related vein, however, I begin with an example that is perhaps at the heart of any philosophical discussion or serious questioning into the meaning, intent, purposes and practice of research and action: conceptualizations of the self.

the self inviolate – the self in process

To consider autopoietic and sympoietic interpretations of the self, I contrast expressions from the Enlightenment tradition and postmodernism. Regarding the former, consider three expressions: Decartes' statement: *cogito ergo sum*; Rousseau's notion that each human is born into the world individual and perfect – only to be distorted and diminished by the prejudice and error emerging from history and social interaction; and the contemporary emphasis on autonomy and individuality evident in car ads and comments such as the following:

> …we know our self with ultimate certainty, even though this knowledge is *subjective*; it cannot be experienced as we experience it by anything else; at best it can only be reported. As noted, we encompass as belonging to the self, or contained within it, our perceptions, our

> thoughts, our ideas, our imaginings, our will, and the actions that spring from them. This is the *inner world*. Everything else is *outside* (Rosen 1991: 40-41).

These conceptions of self carry autopoietic characteristics, with the self viewed as an autonomous entity: internally controlled, bound and clearly distinguished from its environment. In contrast, consider some 'postmodern'[8] conceptions of self, which seem to reflect more sympoietic characteristics. Kristeva, for example, uses the term *chora* in reference to an internal well-spring of drives and energy that constitute the self. She also describes a subject-in-process that is continually incomplete and unresolved (see Kristeva 1986, Mansfield 2000, McAfee 2000). Building on these notions are the following conceptions:

> …perhaps the self is not unified substantially but relationally. That is, perhaps the self is not a thing which undergoes various state changes, but instead just *is* various state changes of consciousness related in a certain manner. In this case, the self would be more like a verb (an organized temporal flow of mental states) and less like a noun (a particular thing). We often unreflectively presume a substantive conception of unity and so naturally assume that states of consciousness can only be unified if they are states of some underlying substratum (the self). But they can also comprise a unity if they stand in a certain relation to one another. In this case no underlying thing is required for unity; indeed, in this case the self would just be certain states of mind properly related (Fay 1996: 37-8).

> The idea of the subject as an open system, a subject-in-process, is a central aspect of what I'll call a model of relational subjectivity. By this I do not just mean Nancy Chodorow's notion that we have the capacity to relate to and nurture others. I mean something much deeper: our very subjectivity is *constituted* relationally, in the relation between conscious and unconscious, semiotic and symbolic, self and other; also in the various political identities that we hold simultaneously. All these relations involve tension, yet at the same time they are productive. As relational subjectivities we are always "under construction," always producing ourselves and each other.
> …we are situated in a web of relationships that continuously construct our very identity (McAfee 2000: 129, xi).

In contrast to the modernist versions, these postmodern conceptions of the self carry sympoietic characteristics: complex amorphous entities, established by relations rather than boundaries. As with ecosystems, however, letting go of boundaries does not imply or lead to a chaotic mess or endless array of components and influences. Instead there is a productive tension continually developing and maintaining a dynamic balance, constituting a nexus of interactions that can be understood as the self.

These contrasting descriptions of the self illustrate the heuristic nature of poietic systems since each expression describes the same thing, but conceptualized in different ways. In the following examples, the negotiable nature of reality comes more to the fore. In each case, I find that the autopoietic and sympoietic characteristics more readily describe *different* phenomena rather than different interpretations of the *same* phenomena: different types of science rather than different interpretations of science and different manifestations of the women's movement, rather than different interpretations of the women's movement. The creative influence of the interpretations in developing the differences that are described is acknowledged in the discussion.

[8] I apply this term loosely to refer to a broad sweep of ideas, concepts and preferences, rolling together under the one name a great variety of different interpretations. As with Decartes, Rouseau, Rosen, there are differences among what I point to as postmodern – the intent is to emphasize the distinction: modern/postmodern, although admittedly done at the risk of blurring distinctions among different postmodern positions. Ignoring boundaries? Producing boundaries? Are there boundaries? …

normal science – revolutionary science – post-normal science

Kuhn's (1970) description of science progressing through normal and revolutionary periods can readily be conceptualized through application of the poietic systems heuristics. In addition, an understanding of post normal science (Funtowicz and Ravetz e.g. 1993, 1994, Ravetz and Funtowicz 1999) – a more sympoietic activity than normal science – can also be gained through such application.[9]

Normal science is textbook science – primarily a puzzle-solving activity with boundaries clearly established through 'preferential neighbourhood interactions' (Maturana and Varela's term) among members of a scientific community. "Normal science… is predicated on the assumption that the scientific community knows what the world is like" (Kuhn 1970: 5). Research proceeds through questions, experiments, observations, interpretations and theorizing that fit within the context of a particular paradigm, and subsequently reinforce belief in that paradigm. Normal science proceeds as phenomena are described and understood. Eventually, however, anomalies arise that can no longer be explained within the paradigm, leading to what Kuhn calls scientific revolutions:

> …the extraordinary investigations that lead the profession at last to a new set of commitments, a new basis for the practice of science… They are the tradition-shattering complement to the tradition-bound activity of normal science (Kuhn 1970: 6).

During the revolutionary period new paradigms are generated through more sympoietic type research: boundaries are opened, leaving systems organizationally ajar. New members and ideas are accepted into the community even if they establish different methods or theories that eventually require change in the paradigm. According to Kuhn's description, a new paradigm gradually becomes established and normal science again predominates. Currently there seems to be increasing cultural preference for these more open qualities, yet it is critical to recognize the importance and value of normal science. The autopoietic characteristics outlined in Table 1 indicates some advantages, including constrained information, steady states, development orientation and efficiency. Kuhn points to some of the benefits:

> When the individual scientist can take a paradigm for granted, he need no longer, in his major works, attempt to build his field anew, starting from first principles and justifying each concept introduced. That can be left to the writer of textbooks. Given a textbook, however, the creative scientist can begin his research where it leaves off and thus concentrate exclusively upon the subtlest and most esoteric aspects of the natural phenomena that concern his group (Kuhn 1970: 20).

> [The] restrictions, born from confidence in a paradigm, turn out to be essential to the development of science (Kuhn 1970: 24).

However, there are also concerns.

> A paradigm can, for that matter, even insulate the community from those socially important problems that are not reducible to the puzzle form, because they cannot be stated in terms of the conceptual and instrumental tools the paradigm supplies. Such problems can be a distraction, a lesson brilliantly illustrated by several facets of seventeenth-century Baconianism and by some of the contemporary social sciences. One of the reasons why normal science seems to progress so rapidly is that its practitioners concentrate on problems that only their own lack of ingenuity should keep them from solving (Kuhn 1970: 37).

Funtowicz and Ravetz (e.g. 1993, 1994, Ravetz and Funtowicz 1999), responding to this type of concern, chose the term post-normal science to argue for development and application of what I interpret as a more sympoietic science. Of particular importance they advocate opening system

[9] This discussion is abbreviated from discussion in Dempster 1998a, 1999.

boundaries by expanding the peer community – making the system of science organizationally ajar by encouraging the inclusion of different perspectives, knowledges, and validation processes. Funtowicz and Ravetz view normal and post-normal science occurring simultaneously, but in different types of situations. The more reductionist autopoietic normal science is considered appropriate in circumstances involving greater certainty and lower risks. Post-normal science is considered appropriate in intractable situations involving great complexity and uncertainty where the stakes are high and where social values and preferences are contentious (e.g. genetically modified foods, nuclear power generation, sustainable forestry).

Post-normal science, however, is a *pre*scriptive rather than *de*scriptive conceptualization – a vision of how things *should be* rather than a statement about how they *are*. As I have discussed elsewhere (Dempster 1998a, primarily 1999), the conceptualization of sympoietic systems may provide a tool to facilitate the manifestation of post-normal science by considering the system characteristics as design criteria – that is, for example, by intentionally crafting the structure of a scientific community to make it organizationally ajar. Consider the challenges that have been observed in trying to incorporate different knowledges into conventional management and decision-making systems, such as incorporating traditional ecological knowledge into the management of natural resources or protected areas. The notion of structural coupling provides a means for understanding some of the interactions involved in this challenge. In simplistic terms, the conventional management systems have structures that are accustomed to dealing with explicit, quantifiable information oriented toward biophysical interactions, such as numbers of species and species associations and recreation measured by the number of visitor-days. To be integrated into the management system, new information must carry a compatible structure. Despite claims to openness and attempts at participatory processes, management systems often remain closed – simply because they do not have internal structures that can allow the successful coupling of incompatible data or information. In effect, boundaries have been produced that admit quantitative data and scientific reports, but restrict qualitative values and personal stories. Developing a system that is organizationally ajar – extending the peer community – will require that the internal structures be altered or developed anew in order to deal with a variety of information, including narratives, qualitative expressions of intransitive preferences and the potential for unexpected shifts or surprisingly new stories.

In addition to designing a system that is organizationally ajar, there is the question of their continuation. Kuhn's description of science as a progression from sympoietic to autopoietic systems may be worth considering with respect to this question. As described, a stage that is open and questioning progresses into a closed practice: normal science. When survival of the operative paradigm falters, a new revolutionary science begins which then progresses toward closure: development of a new paradigm and the subsequent production of boundaries. Is there a 'natural' tendency to become more autopoietic? Is there a 'natural' tendency to develop boundaries? Are the characteristics and advantages of autopoietic systems irresistible? Or perhaps the more appropriate question is: Under what circumstances and in what situations is autopoiesis irresistible? Other examples, include increasing bureaucratization in many fields of practice (NGOs, universities), the development of social cliques and classes, or the emergence of groupthink in some small decision-making groups – each of these examples demonstrating a move toward more autopoietic characteristics.

Here again, however, I am caught by the slippage between that-which-exists and that-which-is-sensed-and-conceptualized. I speak above of boundaries as heuristics and speak now of a 'natural'

tendency to develop them. As discussed at the beginning of the paper, I feel most comfortable taking reality as a process of negotiation. Boundaries – as a means of appropriately conceptualizing phenomena – seem much more sense-able when referring to the skin of on organism, the walls and fence around a jail or gated community, or the cultural norms of an Old Mennonite community. Boundaries seem less appropriate when referring to ecosystems or diverse multi-cultural/multi-ethnic cities. I return to discuss the potential for resisting boundaries in the next example.

women's movement: hegmony? – differential form

As a third example illustrating application of the poietic systems heuristics, I turn to a situation in which a more sympoietic approach is already being manifest: emerging critique and praxis within feminism. In order to more explicitly apply the poietic heuristics in this final example I take a more methodical approach by echoing the descriptive style used above for organisms and ecosystems.

Some might see the 'systems approach' as a rational, analytical, patriarchical methodology unsuited to the following discussion. Yet these systems heuristics have not only enhanced my own understanding, but seem to have facilitated the communication of philosophical, ethical and political implications among people who may otherwise have been unable to understand or gain awareness of such implications.

We generally conceive of social movements to be composed of smaller interacting parts such as people and values working together through a variety of processes to create an identifiable entity: A collective targeted toward manifesting change in the social body. A social movement, then, can be identified by a pattern of organization in which values are connected to goals through people, principles and priorities as well as the processes of communication and protest. Somewhat different patterns of organization are recognizable in the women's movement, the peace movement and those lobbying for aboriginal self-governance. Each of these has different goals and varies in the type of communication and protest that are applied to manifest change. By making finer distinctions, it is also possible to identify different forms of the women's movement. These can most easily be summarized by differences in their goals. Typical categorizations (e.g. Tong 1989, May 1996, Sandoval 2000) can include several different variations such as the following. The equal-rights/liberal form is targeted toward women having the same rights as men. The revolutionary/Marxist form, also views equality as sameness, but emphasizes class distinctions and is targeted toward equal ownership of the means of production. The radical form attends to differences between men and women and is targeted toward achieving equitable valuation of these differences rather than the currently perceived greater valuation of male characteristics and qualities. The radical form can also take a less egalitarian stance, viewing female characteristics and qualities as superior to those of men.

As manifest in action, each of these social movements can readily be interpreted as autopoietic, where the strength and purpose of the system comes from its ability to maintain its identity through continued poiesis by self-producing boundaries and structurally coupling with its environment. Boundaries are produced by the constituents through 'preferential neighbourhood interactions' in order to restrict in/out flows and to maintain an identity distinct and separate from the dominant values, principles and priorities that make-up the environment/context.

Focused on maintaining the goal of women's rights – and holding it resolutely against the dominant patriarchy – the women's movement (liberal form) produced boundaries to keep traditional norms and stereotypes at bay by carefully monitoring, assessing and regulating what entered or who was allowed to become part of the movement. Structural inputs were restricted to those people, principles and values that promoted growth and development – food of a non-organic kind – and were subsequently limited to such inputs as statements valuing women, shouts against discrimination, alternative dress codes and honest discussion of shared experience to establish solidarity. To be let 'in' required fitting with a specific set of norms and practices that were defined by the movement itself.

This autopoietic interpretation of the women's movement – and subsequent consideration of the characteristics outlined in Table 1 – provides some insight into successes, challenges, and problems encountered in its manifestation. For example, an orientation toward *growth and development* of/within the movement allowed clearer definition of what women's rights were. By enabling the development of enough space to gain a different perspective and allow exploration of ideas, a better understanding of how women were subjugated by the dominant norms was possible. As with Kuhn's description of normal science – when members of the community can rely on a particular set of norms and assumptions without 'starting from first principles or justifying each concept', they can 'concentrate exclusively upon the subtlest and most esoteric aspects of the phenomena that concern the group' and pursue more detailed understanding. The firmly held *self-produced boundaries* provided both space and steady state. *Packaged, similar information* and *centralized control* can also be seen in the tendency to gather around particular slogans, directions and actions and in the role of central figures in communicating them.

An autopoietic system's *need to be structurally coupled* is typically viewed as some kind of lock-and-key fit, yet an oppositional coupling is also conceivable. In this case, structures 'fit' by holding fast to a contrasting mirror image rather than by donning a complimentary and acquiescent form. For the women's movement, especially in the early years, 'fitting' (as structural coupling) with the dominant culture meant taking an oppositional stance to whatever was put forward: "If you're not *for* us, you're *against* us." The well worn cliché represents the enactment of a strict and simple binary – and hence boundary – to enable easy maintenance of identity and the creation of a culture for/of resistance. This cliché represents a constructive mechanism for producing boundaries – but also for constructing a (presumably) predictable environment. Rather than provide room for a variety of individual expressions – e.g. male or housewife but *also* an advocate for women's rights – the environment was constructed in a particular way so that if you were a man or a housewife, you could immediately be labelled as a person against women's rights.

Given the high degree of negotiability possible in social situations (as discussed at the beginning of this paper) such an interpretation of the environment/context would be possible even if it was inaccurate. As noted before, the match between that-which-exists and that-which-is-conceptualized-as-existing is not necessarily accurate. This points to one of the key risks involved in being autopoietic. Such systems are more efficient but less adaptable. Efficiency arises from existing in predictable environments and learning (through intellect or evolution) to process inputs. However, there is no guarantee that this environment will continue to be predictable. It may change to a degree that makes continued poiesis problematic or impossible. This is compounded by recognizing the possible discrepancy between the environment-as-sensed and the environment-that-exists.

For many years, the women's movement existed in a predictable environment – one dominated by patriarchy. Some might argue it still is, but (as Kuhn describes for science) sufficient anomalies have eventually led to (at least) some changes – as evidenced by a broader variety of feminisms. In simplistic terms, the women's movement 'worked' for those who were comfortably ensconced as part of the autopoietic system, protected by its boundaries, at ease with its structure and supported by its structural exchange. Anomalies arose from those who lacked fit – in environment or system. Although valorized for manifesting (at least some degree of) change the "white women's movement" has also been criticized for creating a hegemony that silenced voices of different race, ethnicity, sexuality, ability – a criticism arising from those who struggled with the boundaries – the "sister outsiders" (Lorde 1985, 1984), "*mestizas*" (Anzaldúa 1987) and "US 3rd world feminists" (Sandoval 2000). Rather than finding structures of fit within the system, these women were restricted into a "kind of kinetic and self-conscious mobility of consciousness" (Sandoval 2000: 54) moving among different values, principles, and behaviours in order to maintain personal integrity.

> Our strategy is how we cope… how we measure and weigh what is to be said and when, what is to be done and how, and to whom… daily deciding/risking who it is we can call an ally, call a friend (whatever that person's skin, sex, or sexuality) (Moraga 1981 in Sandoval 2000: 59).

These 'mobile members' of the movement lived an everyday reality of "guerrilla warfare," changing values, positions and priorities in order to accommodate or avoid the dominant voices, in order to couple with the system.

These challenges indicate that while the boundaries, control and focus of an autopoietic system provide advantages that enable its continuation, they also have limitations. Firmly held positions become habituated, boundaries become barriers, closure eventually leads to an incapacity for adaptation. As Deleuze and Guattari put it:

> …groups and individuals contain micro-fascisms that only ask to be crystallized (Deleuze and Guattari 1983: 18).

Through its own growth and development, then, and without attention to possible propensities:

> any 'liberation' or social movement eventually becomes destined to repeat the oppressive authoritarianism from which it is attempting to free itself, and become trapped inside a drive for truth that ends only in producing its own brand of dominations (Sandoval 2000).

In articulating an alternative – a movement that attempts to get away from, or limit, the hegemonic drive and to create space for difference, Sandoval describes an approach that is – in contrast – more sympoietic. The 'differential form' enables shifting between and among fixed positions, epistemologies, beliefs etc. The mobile strategies described above change from a reactive survival technique into intentional positive actions that attempt to escape the drive for control and autonomy. The following paragraphs – descriptions characterizing Sandoval's differential form of women's movement – the methodology of the oppressed – easily fit with a sympoietic interpretation.

> …The differential praxis understands, wields, and deploys each mode of resistant ideology as if it represents only another potential *technology of power*. The cruising mobilities required in this effort demand of the differential practitioner commitment to the process of metamorphosis itself: this is the activity of the trickster who practices subjectivity as masquerade, the oppositional agent who accesses differing identity, ideological, aesthetic, and political positions. This nomadic "morphing" is not performed only for survival's sake, as in earlier, modernist times. It is a set of *principled conversions* that requires (guided) movement, a directed but also a diasporic migration in both consciousness and politics, performed to ensure that ethical commitment to egalitarian social relations be enacted in the everyday, political sphere of culture (Sandoval 2000: 161).

> Differential consciousness requires grace, flexibility, and strength: enough strength to confidently commit to a well-defined structure of identity for one hour, day, week, month, year; enough flexibility to self-consciously transform that identity according to the requisites of another oppositional ideological tactic if readings of power's formation require it; enough grace to recognize alliance with others committed to egalitarian social relations and race, gender, sex, class, and social justice, when these other readings of power call for alternative oppositional stands (Sandoval 2000: 60).

I interpret here, a system that is organizationally ajar, that has distributed information and control and a self-similarity that arises from manifesting a tension between change and stasis. Grace, flexibility and strength offer opportunity for structural coupling, yet coupling that supports the potential to resist organizational closure: Strength provides a firmness of structure that offers a fixture to integrate with; flexibility accommodates different degrees and types of fit through a folding/enfolding elasticity; and grace maintains this openness and elasticity despite the tendency for closure and for resistance to, or retraction from, difference. This variable form of women's movement builds on difference, lived experience and dynamic change. It defies the need or desire for boundaries by developing a shifting, dynamic adaptability. It has a pattern of organization that is more ecosystem-like than organism-like, with its boundarylessness enabling it to remain open to different values, principles, priorities and people.

It is possible to remain organizationally ajar? – To resist the formation of boundaries? – To resist the trend toward authoritarianism? To respond to these questions it is useful to consider the distinction between pattern of organization and structure, as it is relevant to the potential for change in the pattern of organization. To remain ajar, sympoietic systems must manifest a structure that can both receive and restrict inputs with the potential to change their pattern of organization. To remain ajar, then, a system must be capable of, and willing to, change on a fundamental level; to alter their identity. For example, in a corporation this would not be about changing the CEO, but about making the position of CEO obsolete. It would not, however, be very likely to mean an *immediate* change from a corporate hierarchy to an egalitarian participatory democratic organization, since the corporation would not have suitable structures for incorporating participatory structures – although perhaps after the CEO is gone…

The system's 'willingness' to change on a fundamental level does not, however, mean willingness on the part of the entire system acting in accord – which would be centralized control. Rather, it refers to a 'willingness' that emerges from the potential for structures from 'outside' to couple with the diverse structures that are 'inside'. If the diversity is too small, the system will be closed; if it is too great, the system will be chaotic; if it is a suitable middling amount, the system remains ajar.[10] The diverse, dynamic differential form that Sandoval has described suggests the latter.

There is another question that arises around this discussion that is worth articulating. In complex socio-cultural systems the distinction between pattern of organization and structure is often hard to portray clearly. In biophysical systems the distinction is quite easy to imagine – the abstract conceptual mapping of relations among components defined generically for a particular system type vs. its physical manifestation in a world you can bump into. In a socio-cultural system where structural components themselves are to some degree abstractions, the distinction is more tenuous (shades of boundarylessness again…). In these cases it may be fruitful to raise a somewhat simpler question: To what is the system open; to what is it closed? In addition, returning to the notion that the pattern of organization is an interactive dynamic blueprint, and structure is its interactive dynamic manifestation, the question becomes: How much is a system open to changing its

[10] One can see a similar argument here regarding biodiversity in ecosystems. A decrease in the diversity of structures, decreases the potential for incorporating new structures, therefore decreasing adaptability and resilience. In effect, the system becomes more autopoietic. Too great a diversity of structures, however, will leave the system open to such a variety of structures and subsequent change that its identity as a system – as something that can be conceived of as a 'whole' – will be at risk.

blueprint? – To changing the instructions it carries or changing its fundamental rule set? Often a system that claims openness will have firmly held rules to describe its manifestation in structural form.

These three examples – the self, science and the women's movement – illustrate application of the poietic systems heuristics to develop understanding of complex situations by contrasting characteristics of the two system types. When I introduced the notion of sympoiesis, I also drew attention to another possibility for considering their development and description: conceptualizing them as self-organizing systems. In order to define systems without recourse to boundary delineation and also to address the concern that, without boundaries there is not stopping, I propose using the factors involved in self-organization as system identifiers or descriptors. To illustrate this possibility I briefly discuss the notion of self-organization and develop some sample applications of the key factors involved, which aid in the development of a richer description of the phenomena interpreted as sympoietic systems.

self-organization

> It is difficult, probably impossible, to find a precise definition of what is understood by a *self-organizing system*. Nevertheless it is an important and useful idea (Andrew 1989: 24).

Despite, or perhaps because of and contributing to, the ambiguity of meaning, 'self-organization' has become popular across a variety of disciplines in both natural and social sciences (e.g. see Cramer 1993, Mainzer 1994). The term is used in reference to many kinds and types of systems – from Benard cells, Belusov-Zabotinski reactions and tornadoes to living systems and political systems (for the range see e.g. Nicolis and Prigogine 1977, 1989; Kay 1983, Perry 1995, Kay and Regier 1999; Dobuzinskis 1987). Although there are obvious differences among these phenomena, and subsequently different expectations regarding their behaviour, the common factor among them is that they can readily be conceptualized as emerging in and of themselves rather than through external direction, manipulation, or control.

> Self-organization is to be understood as the spontaneous emergence of coherence or structure without externally applied coercion or control (Ho and Saunders 1986: 233).

> Self-organization may be taken as the opposite of construction. It probably is due in part to our cognitive make-up, but also to cultural factors in science, that we see the systems of the world as coming into existence under the control of an agent, or according to an algorithm, specified in genes, or in something else. Most people seem to have great difficulty in imagining that order at large, may emerge out of local interactions, without any general plan being present anywhere. And this is exactly what self-organization amounts to (Dalenoort 1989: ix).

Emergence – a concept central to understanding self-organization is perhaps best defined by example. I use the term to refer to the qualitative difference between a collection of bicycle parts and a bicycle; between an assortment of cells and a human. If the parts are arranged in a particular pattern of organization, a bicycle emerges – a structure that has identifiable functions and capacities that do not exist when the parts are organized randomly or in some other pattern. Emergence refers to the qualitatively different behaviours and capacities as well as risks that are present in the whole but lacking in the parts whether the whole is a bicycle,[11] ecosystem, self, or social movement.

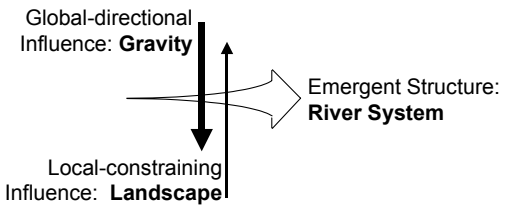
[11] Does a bicycle have boundaries?…

Self-organization, then, refers to those situations or circumstances where the pattern of organization that emerges can be conceptualized as emerging from the pattern of organization itself. Differences in definition or application of the concept will arise from different observers observing different phenomena. Whether a Benard cell, tornado, living organism or social group is conceptualized as 'self-organizing' will depend on the theoretical, epistemological and ontological positions and expectations of the observer. To understand this, two distinctions seem useful. The first is between order and organization (e.g. Wicken 1989, Kay 1983, Dempster 2001b), where order is the simpler concept, referring to a regular, more static arrangement or pattern. Organization, in contrast, tends to imply a functional arrangement of some kind – parts coordinated in a patterned way that leads to some capacity or process. A crystal exhibits order, as does the sorting of river stones along river bottoms or sand into sand-dunes, whereas organisms, ecosystems and social groups exhibit organization. While these examples seem to fit the categories clearly, molecules, mob action and other 'in-between' types of phenomena could be considered ordered or organized depending on the scale and intent of observation. Given these distinctions, some of the phenomena described as self-organizing, such as Benard cells, Belusov-Zabotinski reactions and tornadoes, may more appropriately be conceptualized as self-ordering.

The second useful distinction is between creative and transmitted self-organization (Dempster 1998a), which arises from noting different causal explanations for emergence that loosely parallel studies of physical and biophysical systems. I label explanations of the latter type *transmitted* self-organization because they generally refer to the process by which a system generates itself through internally specified information or code – which tends to be transmitted from one generation to the next. The self-organization (development) of a living organism from genetic information transmitted between generations as an example. This process may more appropriately be termed self-construction (see Kay 1983) or self-production, as described above.

In the case of *creative* self-organization, the process is more spontaneous, with pattern emerging from a convergence of influences rather than from embedded memory. As Haken (1988) emphasizes, a key factor involved in self-organization is that *specific* pattern emerges from *non-specific* influences. I refer to the latter as global or directional influences because they act uniformly on components to provide coherent direction. Formation of a river system – represented graphically in Figure 1 – provides an example. In this case, the global-directional influence is gravity, which uniformly acts on water droplets, directing them 'down'. Interaction among this influence and local-constraining influences, ranging from small soil particles to large geologic features that restrict or alter the direction of water droplets, lead to the generation of coherent patterns: river systems. The ubiquitous similarity of river patterns arises from the generic nature of the interactions from which they emerge; differences arise from differences in the local-constraining influences. Variations in the landscape lead to variations in the emerging patterns, such as the differences between narrow fast-moving whitewater running steeply down rocky slopes and wide slow-moving rivers meandering across alluvial plains (Figure 2).

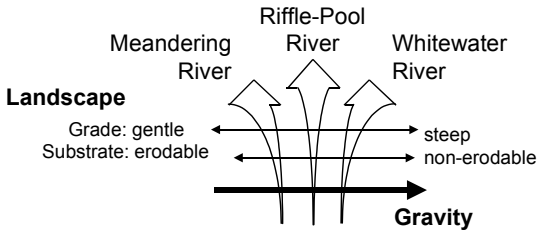
Figure 1. Interacting global-local influences generating river system



(From Dempster 1998)

The second key factor involved in creative self-organization is recursion, especially when leading to positive feedback. While the interaction of global-local influences creates pattern by restricting possibilities, positive feedback creates pattern by reinforcing possibilities. For example, in the generation of a river system, erosion – from the movement of small particles, to the gradual deformation of large landscapes – facilitates the emergence of pattern by encouraging a droplet, freshet or river to follow the direction of the preceding one. It is perhaps this factor that earns such systems the designation 'self'-organizing since their own emerging pattern facilitates further generation of this pattern.

Figure 2. Variations among local-constraining influences leading to different river patterns



(From Dempster 1998)

Given the distinction between order and organization, however, the foregoing description suggests that rivers may more appropriately be considered self-*ordering*. Interactions among *multiple* global-directional and *multiple* local-constraining influences, however, can lead to significantly complex patterns. In particular, the potential for patterns to emerge from interactions among patterns that emerge from interactions among patterns that emerge from interactions… can lead to considerably complex organization. Interactions among self-ordered systems become self-organized and may, in turn, become self-produced. Each of these different types of system could be conceived as a variation along a continuum of increasing complexity.

The third distinction, which seems to be uncommon in the literature, is a question about what 'self' is being organized: How is the system of focus distinguished as something deemed to have the quality 'self' to it or as a 'self' separate from anything else? For example, from a social or psychological perspective – where defining a 'self' typically implies consciousness – the designation 'self'-organizing seems weak even in complicated examples such as an autocatalytic network (where generation of the entity involves feedback processes in which a system's outputs enhance its own creation), a cell or a simple organism – let alone in designating Benard cells or tornadoes. The other part of this question – the potential to distinguish a 'self' from everything else – gets back to the discussion on boundaries and systems. It seems that, in these systems that are designated as 'self'-organizing, there is comfort in designating the phenomena as a 'system' even though the boundaries separating system from environment are less than clear or distinct – or perhaps existing.

One could, however, in thinking about my description of a river system, claim that I have drawn conceptual boundaries by enumerating a limited set of influences as constitutive. Agreeably so. As noted above, I do not argue against the use of boundaries always everywhere, but rather seek a methodical means for identifying phenomena without them. This could be taken as a boundaried description, yet the influences could also be conceived of as boundaryless. Gravity is the obvious example, but landscape – as conceived of here – also lacks boundaries in that no particular part of the landscape, but rather the landscape as a whole, is attributed as having an influence. To develop a more specific description of the system, more specific characteristics of the landscape could be listed. Rather than a typical place-based conceptualization, which relies on drawing boundaries around the watershed, conceptualization could also be done by identifying or describing the range of influences that are present. These might include type of substrate, regulatory influence of dams,

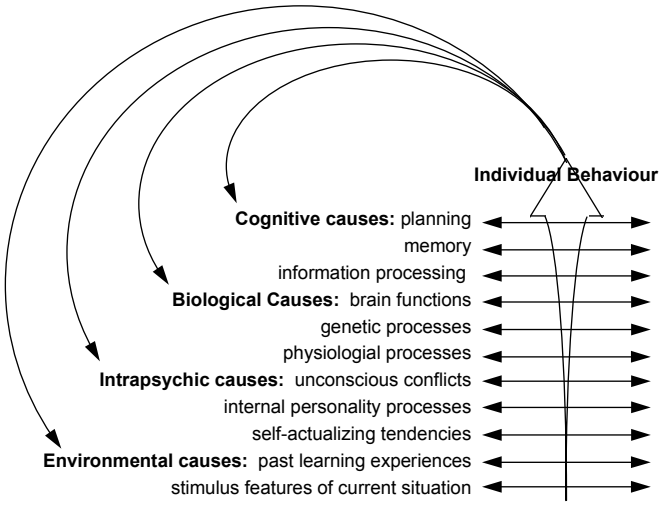
and prevalence and capacity of intakes and outlets – each of these as constitutive factors involved in generating 'the river'. What is included in the description will depend on the observer and their purpose in making the description. For example, a more complex description, integrating social factors could include public demand for water, public fear of flooding, and aesthetic and historic pride about the river that is held by proximate and distant communities. (See Dempster 1998b, forthcoming, for an example relevant to planning in National Parks that incorporates social factors in defining a sandspit.)

To illustrate application of these ideas in social situations, I illustrate two of the examples discussed above – the human self or psyche and science – in a manner similar to that used to describe river systems.[12] Even briefer than the descriptions according to autopoietic and sympoietic characteristics, these descriptions are intended as no more than a taste of the possibilities and should be recognized as illustrative rather than definitive or comprehensive.

the self as a self-organizing system

The first example, Figure 3, illustrates conceptualization of the human self as a self-organizing system. The influences listed represent psychological factors (textbook understanding) attributed with determining the individual human psyche and subsequent behaviour (Smith 1993). The bold titles represent different perspectives within psychology, which point to different categories of causes. More recently, the interplay among them – as illustrated here – is being emphasized. No influence has been given precedence as a global-directional influence (although the different perspectives effectively identify such). Feedbacks have been included to reflect the notion (emphasized by some) that behaviour influences causes, which influence behaviour…

Figure 3. Human psyche as a self-organizing system



Consider as illustrative not comprehensive. (From Dempster 1998)

The list of influences – as well as the illustration itself – both reflect and arise from scientific, reductionist approaches. Yet they are consistent with Kristeva's expression of a subject-in-process and McAfee's comment (quoted above) that "we are situated in a web of relationships that continuously construct our very identity." In addition, compare the illustration – as a representation of multiple interacting global-local influences leading to the emergence of a 'self' – with the following comment, expressing the same interaction in textual form:

> The subject is not a straightforward matter; it is not sufficient to think in order to be, as Descartes declares, since all sorts of other ways of existing have already established themselves outside consciousness, while any mode of thought that desperately tries to gain a hold on itself merely turns round and round like a mad spinning top, without ever attaching itself to the real Territories

[12] These example briefly expand on previous work – primarily Dempster 1998a.

> of existence; which, for their part, drift in relation to each other like tectonic plates under continents. Rather than speak of the 'subject', we should perhaps speak of *components of subjectification*, each working more or less on its own. This would lead us, necessarily, to re-examine the relation between concepts of the individual and subjectivity, and, above all, to make a clear distinction between the two. Vectors of subjectification do not necessarily pass through the individual, which in reality appears to be something like a 'terminal' for processes that involve human groups, socio-economic ensembles, data-processing machines, etc. Therefore, interiority establishes itself at the crossroads of multiple components, each relatively autonomous in relation to the other, and, if need be, in open conflict (Guattari 2000: 35-6).

To me, Guattari's words reflect the same dynamic influence and emergence that are illustrated in Figure 3. Although a tenuous connection for defending any similarity between understandings, this reinforces my sense that no-boundary thinking has its proponents and champions.

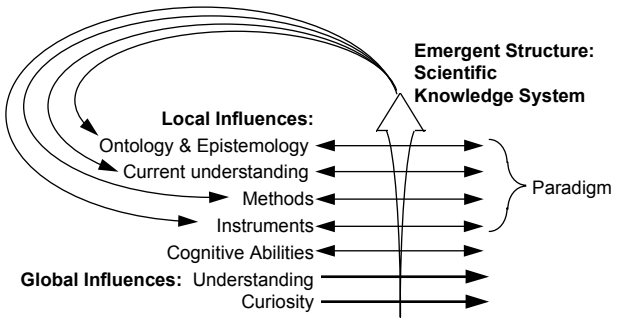
As with the river system, the diagram and description could be considered as bound by the limited number of factors identified as constitutive. Alternatively, no-boundary thinking – such as Guattari's – could be applied, although it may mean releasing preferences for certainty, control, steady states and other (autopoietic) characteristics. As noted earlier, my sense is that (in many cases) boundaries exist if you choose to draw them – although I apply some caveats to this comment in discussion below.

knowledge as a self-organizing system

Different types of knowledge systems also arise from a variety of self-organizing factors (Figure 4). In this case, I have identified key global-directional influences as curiosity and the need for understanding the environment we are embedded within. These two factors impose a direction – not physically, as things are directed 'down' by gravity – but perhaps 'forward' or 'toward' understanding. Aspects of this drive may be felt more by some than by others, and may relate to different areas of interest. At its most basic, however, learning – as movement toward understanding – could be considered a biological requirement for continued functioning (of humans as well as other species).

Learning is facilitated and restricted in a variety of ways including individual capacities and the application of different methods and instruments and will be based on different ontological and epistemological positions, as well as on current understanding. These, then, are the local-constraining influences. In the diagram I have indicated a set of these to match what Kuhn defines as a paradigm.

Figure 4. Self-organizing factors generating science



Consider as illustrative not comprehensive. (From Dempster 1998)

In the same manner that different but similar river patterns arise from different local-constraining influences, different but similar approaches to inquiry arise from different local-constraining influences. As examples, consider hard science emerging from empirical reductionistic application of rigorous scientific method; humanities from intuitive and reasoned application of literary or philosophical inquiry; religion from contemplative or methodical application of spiritual questioning…

As in the previous example – or perhaps *because* of what was illustrated regarding the self – further complexity arises from recursion: the results that emerge affect the organizing influences. As was noted with respect to normal science, for example, activity within a paradigm influences that paradigm: recursion reinforces a particular mode of inquiry as well as the knowledge system it generates and of which it is a part. The success (in this case understanding) of a paradigm reinforces its methods and epistemologies, developing particular understanding, which then strengthens the drive for understanding through the same operative pattern: eureka! *Here* is the way to understanding… Since it is obtained through particular methods, the understanding will strengthen use of these methods and the paradigm, including its ontological and epistemological fundamentals. Since all of these will suit a particular type of phenomena, the understanding that is gained will also strengthen belief in those phenomena – more specifically, belief in those phenomena as they are interpreted through the paradigm. Boundaries are formed unwittingly since only those inputs accessible to the methods and techniques in use will be observed (e.g. visible spectra through a regular microscope or telescope), and only those methods and techniques will be developed that match the paradigm. 'Preferential neighbourhood interactions' (to go back to Maturana and Varela's term), then, are present in the way different instruments, methods, understandings, epistemological positions and other factors interact to form particular patterns of organization (paradigms) – all fed by the drive for understanding.

This conceptualization of a knowledge system as a creative self-organizing system suggests similarities to conceptualization as a poietic system as was described above. A system's pattern of organization is developed through global-directional and local-constraining influences.[13] Structural coupling is recognizable in that only those 'inputs' that are accessible through the methods and instruments being applied will be allowed 'in' – food for the paradigm, so to speak. When the 'food' no longer suffices, the system can no longer maintain autopoiesis and revolutionary science begins, with boundaries opened and new methods, techniques and ideas allowed to enter. Yet, rather than an impossibly messy array of bewildering processes, there is still pattern – a dynamic, but directed complexity of interactions that are recognizable as a knowledge system. These emerge from the creative self-organizing factors – the interactions among global-directional and local-constraining influences as well as recursion – which keep the system emerging from its own interactions.

Closing comment

The foregoing discussion has set out a theoretical platform – based on systems theory – for conceptualizing complex situations and phenomena as boundaryless. Brief examples have indicated possibilities for application, yet have done little to consider the myriad implications that arise. While such discussion would be of interest (certainly to me and hopefully to the reader!) I will not further it here. Instead, I hope the reader has found the ideas interesting and sufficiently well explained to begin consideration of such implications. I look forward to continuing the discussion.

[13] Recognizably this pattern of organization is determined (to at least some degree) by the influences chosen as relevant – just as in the poietic system conceptualization the pattern of organization is determined (to at least some degree) by the identity that is chosen as the focus.

references

Andrew, A. M. 1989 The paradigm of self-organizing systems in The Paradigm of Self-Organization, G. J. Dalenoort, ed.

Anzaldúa, Gloria 1987 *Borderlands [La frontera]: the new mestiza* Aunt Lute, San Francisco

Bednarz, John, Jr. 1988 Autopoiesis: the Organizational Closure of Social Systems *Systems Research* 5(1): 57-64

Bird, Elizabeth Ann R. 1987 The Social Construction of Nature: Theoretical Approaches to the History of Environmental Problems *Environmental Review* 11(4): 255-64.

Bunch, Martin 2001 email communication

Capra, Fritjof 1996 *The Web of Life: A New Scientific Understanding of Living Systems* Anchor Books

Catanese, A. J. and A. W. Steiss 1968 Systemic planning - the challenge of the new generation of planners *Journal of the Town Planning Institute* 54: 172-6

Chadwick, George F. 1966 A systems view of planning *Journal of the Town Planning Institute* 52(5): 184-6

Checkland, Peter 1986 *Systems Thinking, Systems Practice* John Wiley, Chichester

Cramer, Friedrich 1993 *Chaos and Order: The Complex Structure of Living Systems* VCH Verlagsgesellschaft, Weinheim

Dalenoort, G. J., ed. 1989 *The Paradigm of Self-Organization: Current Trends in Self-Organization* Gordon and Breach, New York

Dean, Jodi 1996 *Solidarity of Strangers: Feminism after Identity Politics* University of California Press

Deleuze G. and F. Guattari 1983 *On the Line* Semiotext(e) Trans: J. Johnson

Dempster, B *Developing a ground? For radical praxis - A continuation* Comprehensive Exam, Supplemental - Submitted Jan 31, 2002, Univeristy of Waterloo, Waterloo ON

Dempster, B 2001c *Developing a ground? For radical praxis* Comprehensive Exam - Submitted Aug 22, 2001, University of Waterloo, Waterloo ON

Dempster, B. 2001a *Reality…?* A 'snapthought' web presentation available at: www.fes.uwater.oo.ca/u/mbldemps/

Dempster, B. 2001b *Order vs. organizaiton vs. production* A 'snapthought' web presentation available at: www.fes.uwater.oo.ca/u/mbldemps/

Dempster, B. 1998b *Conceptualizing Complex Systems: A methodology for characterizing systems relevant to the planning and management of parks and protected areas* Technical paper #12, Heritage Resources Centre, University of Waterloo

Dempster, B. 1999 *Post-Normal Science: Considerations from a poietic systems perspective* Jan 29/99 [available at wwwlfes.uwaterloo.ca/u/mbldemps/]

Dempster, B. forthcoming *Exploring the human dimensions of ecological integrity - applying a systems perspective* Proceedings: SAMPA 2000, Waterloo, Ontario, Canada, May 1999

Dempster, Beth 1995 *System Stability and Implications for Sustainability* Unpublished B.Sc. Thesis, University of British Columbia, Vancouver, B.C.

Dempster, Beth 1998a *A Self-Organizing Systems Perspective on Planning for Sustainability* M.E.S. Thesis, University of Waterloo, School of Urban and Regional Planning [available at: www.fes.uwaterloo.ca/u/mbldemps/]

Dempster, Beth 2000 Sympoietic and autopoietic systems: A new distinction for self-organizing systems in *Proceedings of the World Congress of the Systems Sciences and ISSS 2000*, J.K. Allen and J. Wilby, eds. [Presented at the International Society for Systems Studies Annual Conference, Toronto, Canada, July 2000 [available at: www.fes.uwaterloo.ca/u/mbldemps/]

Dobuzinskis, Laurent 1987 *The Self-Organizing Polity: An Epistemological Analysis of Political Life* Westview Press, Boulder, Col

Fay, Brian 1996 *Contemporary Philosophy of Social Science* Blackwell Publishers, Oxford

Fleishaker, Gail F. 1992 Special Issue on Autopoiesis *International Journal of General Systems* 21(2)

Funtowicz, S. O. and J. R. Ravetz 1993 Science for the post-normal age *Futures* 25(7): 739-755

Funtowicz, S. O. and J. R. Ravetz 1994 Emergent Complex Systems *Futures* 26(6): 568-82

Guattari, Felix 2000 *The Three Ecologies* The Athlone Press, London translated by Ian Pindar and Paul Sutton

Haken, Hermann 1988 *Information and Self-Organization: A Macroscopic Approach to Complex Systems* Springer-Verlag, Berlin

Ho, M. W. and P. T. Saunders 1986 Evolution: Natural Selection or Self-Organization? *in Disequilibrium and Self-Organisation, C. W. Kilmister, ed.*

Jantsch, Erich 1980 The Unifying Paradigm Behind Autopoiesis, Dissipative Structures, Hyper- and Ultracycles *in Autopoiesis, Dissipative Structures, and Spontaneous Social Orders, M. Zeleny, ed.*

Jordan, N. 1969 Some Thinking about 'System' *in Themes in Speculative Psychology, Chap 5* London, Tavistock

Kay, J.J. and Regier, H.A. 1999 An ecosystemic two-phase attractor approach to Lake Erie's ecology *in State of Lake Erie - Past, Present and Future, M. Munawar, T. Edsall and I. F. Munawar, eds.* Ecovision World Monograph Series, Backhuys Publishers, Leiden, The Netherlands

Kay. J. J. 1983 *Self-Organization and the Thermodynamics of Living Systems: A Paradigm* Ph. D. Thesis, Department of Systems Design Engineering, University of Waterloo, Waterloo, Ontario

Kickert, Walter J.M. 1993 Autopoiesis and the Science of (Public) Administration: Essence, Sense and Nonsense *Organization Studies* 14(2): 261-278

Kimmins, J. P. 1987 *Forest Ecology* Macmillan Publishing, New York pp 531

Kristeva, Julia 1986 *The Kristeva reader* edited by Toril Moi Basil Blackwell, Oxford

Kuhn, Thomas S. 1970 *The Structure of Scientific Revolutions* University of Chicago Press

Lorde, Audre 1984 *Sister outsider: essays and speeches* Crossing Press, Trumansburg, NY

Lorde, Audre 1985 *I am your sister: black women organizing across sexualities* Kitchen Table: Women of Color Press, Latham, N.Y.

Luhmann, Niklas 1989 *Ecological Communication* (Translated by John Bednarz, Jr.) University of Chicago Press

Luhmann, Niklas 1990a The Autopoiesis of Social Systems *in Essays on Self-Reference,* N. Luhmann, Columbia University Press, New York

Luhmann, Niklas 1990b The Cognitive Program of Constructivism and Reality that Remains Unknown *in Selforganization: Portrait of a Scientific Revolution, W. Krohn, G. Kuppers and H. Nowotny, eds.* Kluwer Academic Publisheres, Dordrecht

Luhmann, Niklas 1995 *Social Systems* (Translated by John Bednarz, Jr.) Stanford University Press, Stanford, CA

Mainzer, Klaus 1994 *Thinking in Complexity: The Complex Dynamics of Matter, Mind, and Mankind* Springer-Verlag

Mansfield, Nick 2000 *Subjectivity: Theories of the Self from Freud to Haraway* New York University Press, New York

Maturana, H. R. 1980a Man and Society *in Autopoiesis, Communication and Society,* F. Benseler, ed.

Maturana, H. R. 1980b Autopoiesis: Reproduction, Heredity and Evolution *in Autopoiesis, Dissipative Structures, and Spontaneous Social Orders*, M. Zeleny, ed.

Maturana, H. R. and F. Varela 1980 *Autopoiesis and Cognition: the Realization of the Living* D. Reidel Publishing Company

Maturana, H. R. and F. Varela 1987 *The Tree of Knowledge* Shambhala, Boston

May, Tim 1996 *Situating Social Theory* Open University Press, Buckingham

McAfee, Noelle 2000 *Habermas, Kristeva, and Citizenship* Cornell University Press, Ithaca, NY

Mingers. J. 1995 *Self-Producing Systems: Implications and Applications of Autopoiesis* Plenum Press

Nicolis, G. and I. Prigogine 1977 *Self-organization in non-equilibrium systems* John Wiley and Sons, New York

Nicolis, G. and I. Prigogine 1989 *Exploring Complexity* W. H. Freeman, New York

Perry, David A. 1995 Self-organizing systems across scales *Trends in Ecology and Evolution* 10(6): 241-244

Pojman, Louis P. 1993 *The Theory of Knowledge: Classic and Contemporary Readings* Wadsworth, Belmon, California

Rasch, William and Cary Wolfe, eds. 2000 *Observing Complexity: Systems Theory and Postmodernity* Minneapolis: University of Minnesota Press

Ravetz, J. R. and S. Funtowicz 1999 Post-Normal Science - an insight now maturing *Futures* 31(7): 641-646

Roe, P. H., G. N. Soulis, and V.K. Handa 1992 *The Discipline of Design* University of Waterloo (Reprint, orig 1967)

Rosen, Robert 1991 *Life Itself: A Comprehensive Inquiry Into the Nature, Origin, and Fabrication of Life* Columbia University Press, New York

Sandoval, Chela 2000 *Methodology of the oppressed* University of Minnesota Press, Minneapolis

Smith, Ronald E. 1993 *Psychology* West Publishing, St. Paul

Tong, Rosemarie 1989 *Feminist Thought: A comprehensive introduction* Westview Press, Boulder

Varela, F. E. Thompson, and E. Rosch 1991 *The Embodied Mind* MIT Press, Cambridge, Mass

Varela, F., H. Maturana, and R. Uribe 1974 Autopoiesis: The organization of living systems, its characterization and a model *Biosystems* 5(4): 187-196

von Glasersfeld, Ernst [2001] Distinguishing the Observer: An Attempt at Interpreting Maturana www.oikos.org/vonobserv.htm [Jan 27, 2001]

Weinberg, Gerald M. 1975 *An Introduction to General Systems Thinking* John Wiley and Sons, New York

Wicken, Jeffrey S. 1989 Evolution and Thermodynamics: The New Paradigm *Systems Research* 6(3): 181-186

Wilber, Ken 1985 *No Boundary: Eastern and Western Approaches to Personal Growth* Shambhala, Boston

Wolfe, Cary 1998 *Critical environments: postmodern theory and the pragmatics of the "outside"* University of Minnesota Press, Minneapolis