RE-FRAMING SYSTEMIC PARADIGMS FOR THE ART OF LEARNING

Donald H. McNeil
[redacted]

Abstract

Thoughtful people are increasingly concerned that the current paradigms for social, corporate, and educational activities are in disgraceful disarray. The "problem-solving" or analytical model, the competitive or game model, the commercial or consumer model, the bureaucratic or institutional model, and the disease or illness model which prevail in public discourse are proving to be especially unwholesome. We cannot, however, educate ourselves without paradigms. A credible educational paradigm must be generally accessible without being simplistic, informative without being monothematic, and accommodating as well as discriminating. Given our disquiet with the current cognitive situation, a renewing paradigm must be somehow novel; given the character of human nature, a sustaining paradigm must be somehow familiar.

For a very long time now, professional Sciences have committed themselves to paradigms about "reality out there," while professional Arts have devoted themselves to expressing "imagination from within here." The more these two worldviews polarize in opposition to one another, the more room there is — and the more human need there becomes — for mediation by an applied philosophy which accommodates the "real" as well as the "imaginary" in a complementary way. Such a philosophy would address not only "what do you know?" and "how do you do?" but also "how do you know?" and "why do you do?" In earlier times, people would have been considered neither educated nor wise unless they appreciated the Sciences and the Arts whole. In our time, we may not survive unless we can re-integrate our fractured perceptions. How might we proceed to do so? There may be a systemological way.

Keywords: systemology, general systems, toroidal topologies, homeokinesis, heterarchy, purpose

Introduction

For more than half a century now, there has been an undercurrent of concerned thought about how we might better understand our perceptions of composite wholes defined relative to environments and relevant to purposes. The founders of this subject matter called it "General System Theory" and later "General Systems Thinking." Those who have popularized it in the meantime have often reduced it to cliché as "the systems approach" or to technology as "systems analysis." In this paper we shall re-assert the integrity of *system* — properly construed — as an appropriate subject matter for study in its own right and refer to it simply as "systemology."

In World Futures Vol. 46, pp. 23-45
(1996) Gordon + Breach
Originally presented at ASC Meeting 11/'92

Systemology focuses our attention on stasis amid flux, order despite change, connections notwithstanding boundaries, loops among links. Since early days, systems theories have been informed by cybernetics. More recently, they have benefitted from findings in researches as wide ranging as "purposeful systems," "artificial life," "complexity," and "chaos." Nowadays it is becoming possible at last to articulate the core of a general theory of systems, to apply that theory, and to establish a coherent systemological frame of reference.

To be concerned with a system is to attend to "the big picture." But how big is big enough? And what are the contours of the picture? An archetype for systemology is to be found in a perspective of the living tree shown in Figure 1. Visualized as a dynamic process as well as a physical entity, the tree is a circulation as well as a thing, a toroidal whole with a wooden hole in the environment. By applying our art as well as our science to the design of systemological paradigms, we may make common sense of the enlightenment available in uncommon perceptions. This paper explores these possibilities in words and pictures.

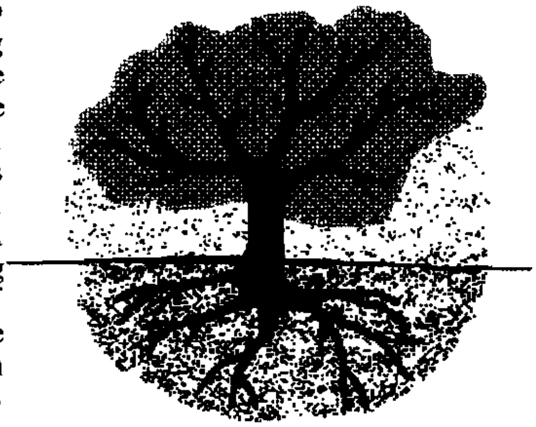

Figure 1

All Hallowed Shells

Humans organize their knowledge around paradigms: mental models of how the world works. Paradigms serve as heuristic tools with which to acquire knowledge and as mnemonic devices to retain it. They may be implicit or explicit. They may be formed into more or less clear pictures or articulated in more or less pithy maxims. They may be received from an ambient culture or created in an individual imagination. Whatever may be their shapes or their sources, paradigms provide the standards against which people measure their perceptions, their cognitions, and their actions. It is a principle of cybernetics that the extent of control which any system has in its environment depends upon the extent to which that system models that environment [3]. The progress of an art of learning depends, therefore, upon the fidelity of its worldview to the world.

The human brain is a remarkable organ, but even its best efforts are puny considering the plethora of things which there are to know. It seems that the animal in us has evolved to cope with gradually changing "natural" environments, but a turbulent artificial world bewilders us with its chimeras and its pace. We respond by simplifying. Our every paradigm is necessarily abstract and under-dimensioned, a more or less unwarranted generalization. We compensate for conceptual inadequacy, insofar as possible, by reacting to the particulars of situations on their own merits. Where particulars do not fit our paradigm, however, our worldviews become ever the more fractured. Several rather incompatible — even incommensurable — paradigms may be adopted: one for home, one for business, one for science, one for Sunday, etc. The resulting confusions produce a debilitating wear and tear on the character of individuals, communities, and civilizations alike.

Cultures cultivate paradigms; for example, the Americas have cultivated the paradigm of the frontier, a place where "might makes right" in the race to exploit a succession of attractive lodes. Some say that a frontier culture still prevails in the USA, but clearly there are other paradigms operative nowadays. Among the most popular of these is the paradigm of the "game" through which "teams" achieve their "goals" by "beating" the "competition." Another is the clinical paradigm of disease which sees every deviation from the "normal" as an illness to "diagnose," "treat," and "cure." There remains the ever popular paradigm of the bureaucracy which slots every subject (and every person) into a "hierarchical" organization. And certainly there is the commercial paradigm — now triumphant after the fall of communism — which promotes the "growth" of "industry" and "productivity" for "markets" where values are determined by "pricing" and "competition." Perhaps the most prevalent and insidious of the popular paradigms is that of "problem-solving," ostensibly derived from analytical scientific methods and therefore deemed "good" for a technological age. It is based upon the premise that as people wander through life they are recurringly confronted by "problem situations" which it is their duty to reduce to puzzles and "solve."

It is perhaps too easy for a thoughtful person to debunk these paradigms. All of them are simplistic in the extreme, and most are very short-sighted. Monotonic and monothematic, they do not even get the signs of their feedbacks right. One way or another, each does violence to its subject matter. Each is a more or less hacked cropping of a bigger picture. The game model lacks any appreciation of the myriad ways in which variegated symbioses and viable niches transcend cutthroat competition in the cybernetics of mature ecosystems, even as the business of "playing the game" cashes out of any semblance of sportsmanship. The clinical paradigm neglects fundamental well-being insofar as it fails to promote a wholesome milieu as the prerequisite for healthy people and habitats. The bureaucratic paradigm imposes order at the price of coercion by artificial compartmentalization. And the commercial paradigm forgets, among other things, the cooperation and the stewardship upon which every viable community depends.

Although the "problem-solving" paradigm seems superficially to be more realistic and less political than the others mentioned above, it has a peculiar bias toward a lurching reactivity, as if the most characteristic of human impulses — the pursuit of purpose — were only of peripheral importance. Insofar as foresight is accommodated in this paradigm, it tends to be limited to the anticipation of "probable" happenings, thus discounting the developments which are caused by human initiatives, intentions, and plans. It pretends to "objectivity" and the particular rationality of a linear world which is reducible to "things out there." It presumes that a technological arsenal of "problem-solving tools" could mechanize and eventually offer mastery of prediction and control. Ultimately, the "problem-solving" paradigm provides at best only a patchwork of partial, local, and temporary "solutions" to "problems" which are themselves the results of "solutions to problems" ... ad infinitum.

As flawed as the popular paradigms may be, they are nonetheless appealing, not only for their apparent simplicity but also in their supposed benefits. If we recognize the political exhortations implicit in paradigms such as those in the sampling above, however, we are better prepared to ask <u>who benefits</u> where one or more of them is adopted wholeheartedly. Each represents a deliberate philosophical agenda, and what each leaves out is as significant as what it affirms. If we are concerned as to whether such paradigms model a wholesome reality, it behooves us to ask a few pointed questions. Where do these popular paradigms come from? Do any of them really work? For how long? What assumptions, if any, do all of them have in common? How — if at all — do paradigms such as these contribute to our understanding of the embracing continuities and grand cycles at every scale in the world? Where in these paradigms is there an appreciation of the details of artistic values, the big picture of environmental contexts, and the deeper essences of human meanings, of character, and of conscience? And who would want to live in a world where any one or a combination of these superficially convenient and expedient paradigms was predominantly held to be true?

In former times it would have been the work of Philosophy to examine such questions and to provide society with access to some provisional answers. Nowadays it would be derided by popular culture as an unworthy academic exercise even to consider these questions and dismissed as politically incorrect to ask them out loud. As a "practical" matter we would be safer to subscribe to the meta-paradigm that conditions us to adopt whichever paradigms are expedient, i.e., "When in Rome, do as the Romans do." After all, the best and brightest of worldly leaders tell us to "be competitive" while the most successful of entrepreneurs advise us to "support the team." To adopt the paradigms of popular culture would only to be to follow one of the oldest meta-paradigms for learning: "If an authority says it, then it is true." Why not place our confidence in the game?

Into the Breach

In every age, there are a few misfits who question the conventional wisdom. Nearly half a century ago, it became overwhelmingly apparent to a number of maverick scientists that the paradigms — technical and social — of modern times were sterile and exhausted. At the same time, they were seeing the coherencies within particular fields of specialty as well as the similarities of order among different specialties as more than merely coincidental [10]. The founders of the "systems movement" believed that a General System Theory could be developed which would, among other benefits, re-integrate the fractured sciences by articulating the principles which are common to them all. As witnesses to an increasingly awful human alienation in a milieu where technology, commercialism, and militarism had run amok, they hoped that their work would lead to a more enlightened and wholesome world.

For several decades thereafter, a subculture devoted to the "advancement of general system theory" made remarkable progress, sponsoring international conferences, spawning university departments, and providing an incubator for ideas which had no home within the established fields of specialty. All was not well, however. The word *system* became cheapened by its identification with particular technologies such as computers or with particular methods such as "systems analysis." Much worse, the central principles of a systemological revolution were never constituted into a competent core of theory which could facilitate education, enhance communication or inform worldly applications. This has not prevented the spread of a desultory "systems practice" in whose name almost any "interdisciplinary" indulgence may be committed. The result, after all, is that the "general systems movement" which was supposed to offer a newly tractable, credible, and accessible worldview has only added another specialty to the babble of academic confusion.

We should not be surprised that the prevailing paradigm of a putative General System Theory has not gained popular acclaim. Where other paradigms promise the excitement of "the game" or the gratification of commercial riches or the omniscience of "scientific objectivity," the systems movement has only been able to offer the mental model of a system as "a set of objects with relationships between the objects and between their attributes" [6]. If that is not inspirational enough, we can hark to murky murmurs about "hierarchy" and "self-organization" and "wholeness." If we remain unimpressed, we can go still further and attend to cybernetical notions of "inputs" and "outputs" and "feedback," yet however important these and a laundry list of other "systems" ideas may be, they remain disjointed. To its discredit and its disgrace, conventional "systems science" sets forth a far less cogent paradigm with its "sets with relationships" than even the most superficial of the popular paradigms or the metaphors of the established sciences do. It seems after all that the technocrats and their athletic supporters have won the game while the world goes to pieces.

It is beyond the scope of this paper — or perhaps of any book — to criticize properly the paradigms of a popular culture or to address adequately the questions posed about them in the previous section. Indeed, to attack or to defend those paradigms on their own merits would likely degenerate into sophistry about politics or dogma. Moreover, meta-paradigms such as those of expediency or authority would have to be brought into question as well, further compounding the complications. This paradigmatic miasma will stew in its own broth until and unless a substantially more felicitous meta-paradigm is offered. A competent alternative would subsume and reconcile paradoxes while it extended the scope and the depth of our appreciation for the world at large. Moreover, it should provide a principled architecture for understanding how the world works, even as its epistemology would be accessible for laymen to check for themselves. To accommodate human frailty, a wholesome paradigm must have a simplicity in kind yet carry a generative immanence. Beyond cognition and rationality it must be aesthetic and kinesthetic. It must embrace cyclicalities, respect continuities, and apprehend consequences. Ultimately, it must acknowledge values, accommodate purposes, and inform conscience.

Talking Generalities

It was in the spirit of the original "systems movement" to presume to offer a grand mediating paradigm to harmonize the dissonances of a fractured world. Since paradigms about "sets with relationships" and other kindred explications of "system" have failed, there will have to be another way. We might recapture the sense of *system* by reconsidering what it means to be systemic. First and foremost, to be systemic is to be orderly and repeatable. The order may be as simple or as elaborate as any conceivable pattern can be. The repeatability — itself an ordering — implies intervals and timings such that similar orders can be found to recur in different places and at different times. The combined effect of systemic order and repeatability is to produce an ordered loop or cycle of an ordering, i.e., a dynamical, volutionary organization.

A second criterion for being systemic is that orderliness and repeatability remain persistent despite changes in the system and in its environment in a kind of homeokinesis. Indeed, a distinguishing characteristic of being systemic is to persist, even in the presence of disturbances which would break a structure or scatter a set. Neither the orderings nor the repetitions of persistent systemicity need be rigid or exact as long as they remain recognizably similar, but that very recognition is made possible by perceived continuality and persistence. For example, an eddy in a stream is continually changing yet continually itself.

A third criterion for being systemic is that the orderly and repeatable whole is composite: there are two or more identifiable constituents in an order and two or more distinguishable phases in a repeating sequence. Constituents are not, in general, separable from the whole as "parts" and may be as integral to the whole as the eye is to the hurricane. There are, of course, many systems which have more or less separable constituents, articulated as subsystems or components or organs or members or cells or parts, each of which has some recognizable structural and temporal identity of its own. In the limit, such a partitionable system reduces to a machine, albeit perhaps a very abstract one characterized entirely by "states" and "transitions" [2]. In general, however, the whole system and its constituents are inseparable, at least to the extent that neither the whole nor the constituents would be the same without the other, and the whole transcends any particular partitioning.

A fourth criterion for being systemic is to be realizable and consistent. This does not mean that virtual and imaginary factors may not be present but only that these factors must ultimately reconcile with "natural law" in such a way as to make the overall system feasible. In this context, "natural law" is no more or less than the order which governs the possibilities which natural phenomena — including humankind — can actualize, whether or not all of that "law" happens to be within human ken. Such law may obstruct or constrain, but it may also serve as an instrumental means, e.g., as a large rock might be encountered as a stumbling block or utilized as a stepping stone.

Finally, to be systemic is to be delimited, i.e., distinguishing what is included in the repeatable order and what is excluded. Thus a systemic whole does not include everything in the universe but rather defines what is to be considered interrelated within the boundary which separates the system inside from the environment outside. The boundary is more or less open — linking the system to its environment through interfaces for inputs and outputs — but the essential order, repeatability, persistence, and constituency of the system remain within, at least as far as the person who defines the system is concerned.

The five criteria above are together essential to an apprehension of "being systemic" and hence to an appreciation of what a "system" — properly so called — may be. There is another consideration, however, in a thoroughgoing definition of systematicity: the purpose for which a system is defined to exist as such. By *purpose*, we mean a percipient's *intended end.* In general, the purpose of a system does not originate within the system itself but rather in the consciousness of the percipient who defines the system. Therefore we say that every system is defined relevant to purposes [7]. This is especially noticeable in the ways that boundaries for inclusion and exclusion are established [4], but it certainly applies as well to the discrimination of constituents [3], the recognition of persistence, and the identification of what is orderly and repeatable [11]. What the ordering principle is, and what counts as an input or an output across the boundary, are among the most idiosyncratic manifestations of intentionality as well as of perceptivity wherever a system is defined.

A system, defined for a purpose in terms of the organizing principles above, is more like a setting than like a "set." It establishes a *frame-of-reference* for the purposeful percipient. Boundaries of the whole and the structure of the constituents lend **form** to the system; inputs and outputs across boundaries produce behaviors which are interpreted to be the **function** of the system; the substantial composition of the system is seen as its **content**; and the continual reordering of systemic action with reference to its organizing principles educes its **control** relative to the percipient's purposes [9]. Thus do three classical complements — *content*, *form*, and *function* (albeit sometimes identified at a different level of discourse as *substance*, *structure*, and *process* respectively) fit together with *control* (or *governance*) as the four essential aspects of a systemological frame-of-reference. The characteristics of systems in general, then, can be identified with these four mutually-complementary aspects. Whatever else it may prove to be, a general theory of systems is a general theory of how frames-of-reference can be established.

In all of the commentary about systemicity so far, the factors of **timing** and **scaling** have been implicit. Both must be considered explicitly in the constitution of a systemic definition. Moreover, the boundaries and the constituency which a percipient defines for a system imply not only an inclusiveness but also an echelon of order in which the system has two or more subordinate constituents and is itself a constituent of one or more supersystems.

Taking together the ideas developed above, it is possible to articulate a definition of "system" as follows:

> At a given echelon of order, a *system* is a dynamic, organized, delimited, open, persistent, composite whole. It is volutionary, comprised of at least one loop and at least one link which manifest the aspects of **content**, **form**, **function**, and **control**, together with **timing** and **scaling** factors, relative to an **environment** and relevant to a **percipient**.

This definition represents what *systemology* is about. If we accept the definition above, we have advanced well beyond "sets with relationships." In it we have a succinct rendition of the constitutive central concepts of systemicity. To define the action of systemic defining in this way is a fine academic exercise, but we remain nonetheless some cognitive distance away from a recognizable paradigmatic form. Images beyond words are needed.

Reinventing the Wheel

The wheel (Figure 2) is conventionally said to be the greatest single invention of mankind, proof positive that he is the best and brightest, surely superior to all other creatures under the sun. The wheel is indeed remarkable in more ways than as a means of conveyance. In the form of pulleys, rollers, and gears, wheels provide the mechanical advantage of a lever but deliver it in continuous cycles. Even more remarkable and mysterious is the effect of a wheel's spinning which at once stores energy, conserves angular momentum, and establishes a gyroscopic orientation in space, hence applications such as flywheels and gyro-compasses. Although biological evolution did refrain from deploying the wheel-and-axle directly in the locomotion of its creatures, there is no dearth of wheeling and gyrating phenomena throughout nature. Perhaps the most elementary example is the rotation of the Earth on its "axis." The orderings which spin off from this rotational dynamic suggest many other images of volutionary systems [13].

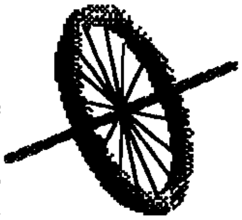

Figure 2

We can increase our apperception of a systemological paradigm by revisiting and re-visualizing natural phenomena which are commonly understood as systems. For example, it is conventional to describe climate as a sequence of weather *systems*. Any one such system may be manifest as a rather diffuse circulating "high" or "low" or as a very concentrated maelstrom such as a tornado. An example of a weather system is a hurricane, represented by the sketch in Figure 3. Perceived in perspective, a hurricane appears as a circulation of moist air powered by a central updraft of the same. It has a definite life cycle from its formation in currents and crosscurrents through its wanderings as a consolidated storm until it disperses when the thermal gradients which have sustained it dissipate. It is consubstantial and monophasic, consisting of moist air throughout, albeit with various degrees of condensation of its water vapor and different molecular energies. The shape of the hurricane persists as a stasis amidst flux — rather, as a homeokinetic formation constituted of fluxion — despite continual transfusions, diffusions, and exchanges of its substance, retaining its identity regardless of whether its constituent molecules remain the same. Its boundaries are ephemeral and fluctuating but may be identified nonetheless as its "eye" and its "flanks." Exactly what delimits its center or its periphery is a matter of perception and of definition. The hurricane is a whole around a central hole in a most fundamental way. It cannot be taken apart or reduced in its echelon of order without vanishing. We can speak of a hurricane's "parts" such as the "eye" and the "gale" and the "flanks," but each of these is perceived in an imaginary partitioning, and none has any meaning or existence without all of the others in the whole. Although its constituent circulations and turbulences are indescribably convoluted, its general shape — like that of a wheel — is a doughnut or torus.

Figure 3

Botanical systems offer a somewhat different apprehension of natural patterns. The living tree is at once an organic whole, a composite of biochemical subsystems, and an active constituent of a larger ecosystem. A tree is a heliotrope and a hydrotrope, a structure and a process of substance and organization. It has localized as well as global flows and counterflows. It manifests relatively rigid, solid shapes close to its center as well as very ephemeral and intermittent patterns of activity around its periphery. A systemic view of a tree — or indeed of any plant — is as a virtual torus of physical, chemical, electrical, and biotic processes in circulations large and small, with embracing loops along the trunk (or stem) as a center for circulations from roots to branches and back as suggested by the illustration in Figure 4.

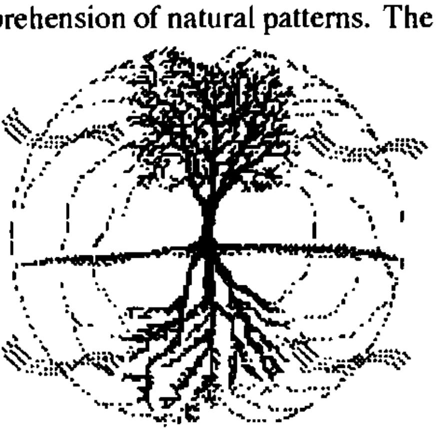
Figure 4

Seen in this perspective, a tree trunk is a (wooden) hole in the ambient air with roots and branches fanning out toward the periphery of contingent effects, linked by atmosphere, ground water, birds, insects, bacteria, chemical reactions, etc., through the larger world. After developing more or less rapidly from seedling to maturity the tree stabilizes as an operational system. Leaves dropped from the branches decay and contribute to the fertilization of the roots, while photosynthesis in the leaves captures energy to power the entire plant. The tree is oriented toward sources of sunlight above and moisture below. There are influxes from and outflows to its surroundings. All of the processes surrounding the life of the tree are balanced in throughput, timing, scale, and proportion so that the healthy tree is not buried by its own falling leaves or choked on its own transpiration or exhausted by trying to bloom out of season. Eventually, the tree as a system succumbs and dies, thus completing a systemic life cycle, yet contributing through its decomposition to other cycles and systems.

From the perspective of the figure above, the living tree offers a felicitous archetype for a whole system, complete with loops and links, persistent order amidst change, influx and effect. The tree perceived in full respect as a system is not merely a "set with relationships" or a "hierarchy" but rather an organic toroidal whole with roots as well as branches, virtual flanks as well as a tangible stem. Although the entire system of a single tree is impossible ever to grasp, it is surely no less inclusive than the tree in its fully toroidal context. Although it is vari-substantial and polyphasic, its toroidal form resembles other conventionally perceived systems, such as the hurricane. It is centered, oriented, organized, and — at the echelon of order where it is identified — irreducibly whole.

The Doughnut Whole

From observations of two very differently constituted natural systems — the hurricane and the living tree — it is evident by inspection how to perceive the contours of archetypal systems as toroids. Upon reflection it is also apparent that, one-by-one, the entities conventionally identified as systemic such as magnetic fields, electrical circuits, chemical reactions, living biotic cells, transactions of social exchange, circulations of blood in living creatures, eddies in a stream, orbiting planets, whirling galaxies, atomic valences, spinning gyros, attractors and repellors, and even the programmatic cycles of computational processes each manifest toroidal loops and links. These systems may be actual or virtual, continuous or intermittent. They may be more or less consubstantial, more or less polyphasic, more or less ephemeral, more or less abstract. They may be the loci of dynamic traces or the residues of dynamic flows. They may be relatively open as vortices or relatively closed as doughnuts. Nonetheless, they all fit in with a "common sense" perception of *system* which must, in turn, be reconciled with any formalized or technical concept of "system."

In general, systemicity is defined where there is perceived to be a cyclical order of a cyclical ordering. The contours which appear ubiquitously where systems are visualized in full respect are therefore toroidal. Topologically, a simple torus is the three-dimensional figure described by a rotation around an axis (an order) of a closed two-dimensional figure (an ordering) as indicated in the illustration in Figure 5. Note that a torus may be extruded as a pipe or flattened as a disk. It may even be deformed and reformed, e.g., into the shape of a teacup, or twisted and knotted without changing its fundamental topology.

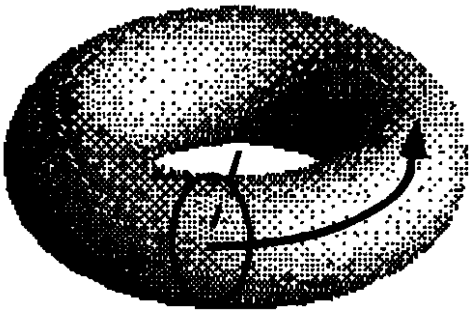

Figure 5

Natural as well as artificial toroids can be generated in many ways other than by the rotation of a plane figure, e.g., by convection as in the system of weather, by accretion as when a candle's wick is repeatedly dipped into wax, and by the compounding developmental patterns as in the growth of a living tree. Toroidal forms can be traced by continuous spirals of helical dynamics, such as illustrated in Figure 6 or in a complementary way as in Figure 7. These are only a few examples which suggest how a continuum of motion can naturally close upon itself in a re-cyclical toroid.

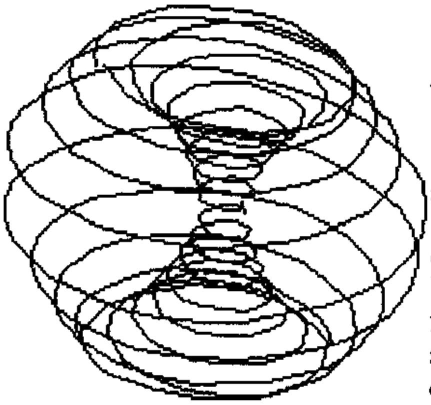

Figure 6

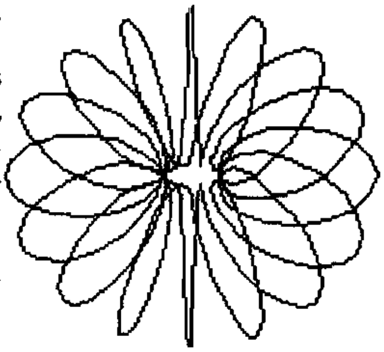

Figure 7

The torus has very many consequential topological features which a simple sphere or spheroid does not. For the purposes of a systemological definition, however, one of the most important of these is the way in which the torus represents a break in the three-dimensional symmetry of a sphere. The torus is thus an oriented figure which can channel, direct, select, and control along its axis, e.g., as a duct, a channel, a conduit or a pipe.

As powerful an organizing principle as the volution of a cyclical order into a torus can be, it would not represent the complexity of the real world very well if its topology were limited to the contours of a simple doughnut or wheel. It turns out topologically, however, that generalized toroidal surfaces may not only be deformed and/or convoluted and knotted but also that they may incorporate more than one hole or center as illustrated in Figure 8. Again, note how control is manifest through the holes as in a sieve, mesh, screen or filter.

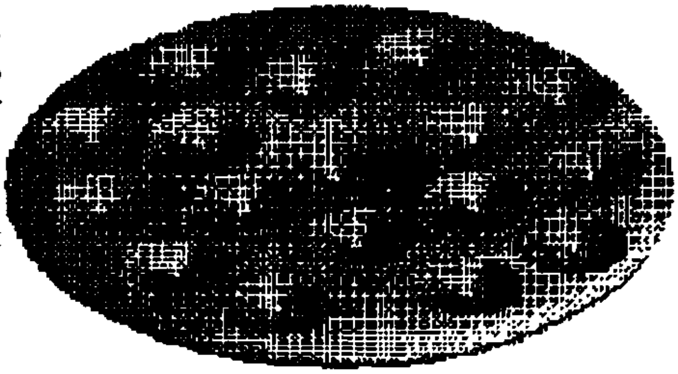

Figure 8

In a topologically similar, i.e., homeomorphic, pattern a constellation of toroidal weather systems or a forest of toroidal plants taken together constitutes a larger polytoroidal system. Very elaborate polytoroids with convoluted manifolds and branching manifests are also commonly identified as systems throughout nature, e.g., nervous systems and circulatory systems, which are homologous to polytoroids such as the one shown in Figure 9. In general, toroidal fluxions may be richly interwoven with one another and may have more than three dimensions.

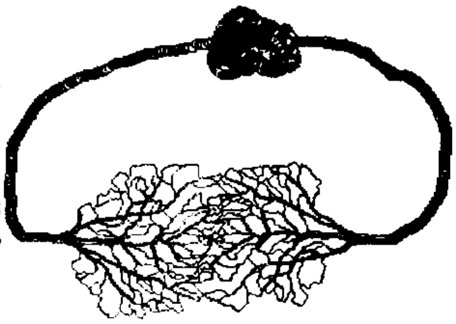

Figure 9

Examination of archetypal systems in a toroidal context suggests how we might reframe and reconceive existing knowledge about systems so as to realign sciences and systems with natural philosophy. If we let go the notion that systems per se can be satisfactorily understood at the level of discourse of "sets with relationships," it is much easier to place the idea of *system* into perspective. A unitary system at a given echelon of order can then be defined to include at least one toroidal center so that no whole system is less than a toroidal circulation. This establishes a relatively "objective" reference for what and where a given system is. The percipient has the last word, however, defining which center(s) and how much of the surroundings are to be included [11]. In this way, the definition of a particular system is at once anchored in reality and delimited by the imagination.

Reforming the System

In a toroidal paradigm, concepts associated with systemic thinking can be apperceived — re-cognized — in context. For example, the conventional idea of "hierarchy" could appear as an abstraction of a cropping of the aspect of "structure" or **form** as suggested by the illustrations in Figs. 10 - 12. From the generalized toroid with its stem highlighted as in Figure 10, a cropping may be articulated as shown in Figure 11 which can then be further abstracted to derive the hierarchical figure in Figure 12. This serves as a reminder that a system is not well-represented by a hierarchy and that a hierarchy is not "the system" but rather only a cropping of an aspect of the heterarchy of the toroidal whole [8].

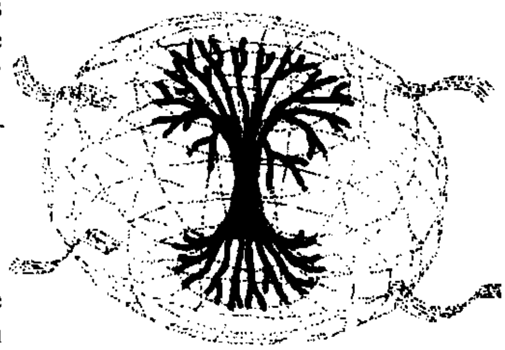

Figure 10

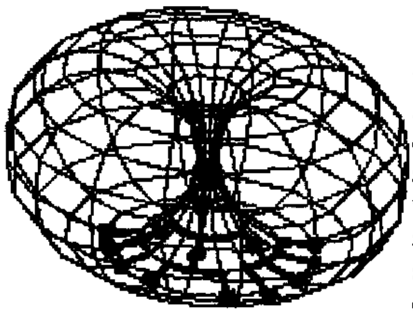

Figure 11

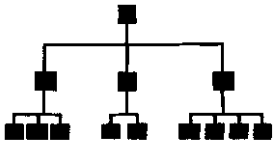

Figure 12

From a different perspective but in a similar spirit, the aspect of "process" or **function** — in particular the idea of a functional feedback loop — may be derived by rationalizing a toroidal flux as indicated in Figure 13.

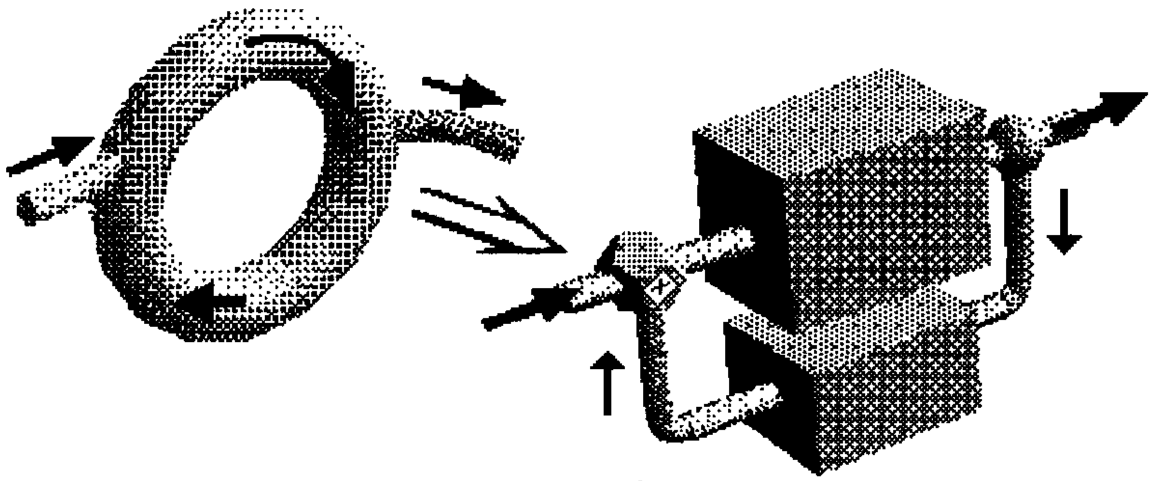

Figure 13

Of course, this rationalization can be carried further, ultimately to be abstracted into signal flow diagrams and the formulas for transformations and feedbacks such as those fundamental to cybernetics.

Although **form** and **function** (or their respective homologues "structure" and "process") are the two most often acknowledged aspects of systems in the literature [1,2,7,10,11], two other primary aspects become evident in a toroidal systemic paradigm. Of these, the most often neglected in the systems literature is the aspect of "substance" or **content**, but it is nonetheless essential to an appreciation of systemicity. In a systemological paradigm, the content is that which flows or circulates or constitutes. The circulation of content in a laminar flux across a vortical crosscurrent of fluid offers an example of homeokinetic stasis amidst flux as suggested by the illustration in Figure 14.

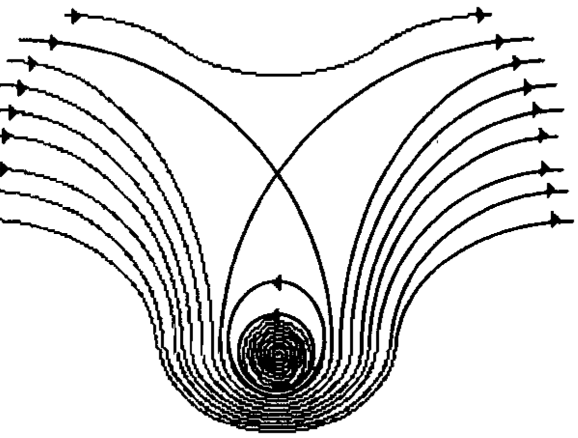

Figure 14

Finally, from still a different perspective, "governance" or **control** is identified with the cybernetic aspect of systems. Understood systemologically, "control" is the re-ordering of activity with reference to ends. In a toroidal paradigm, manifestations of control can be identified with the orientation and strength of a toroidal center, taken as a channel, a stem, a conduit, or even a gyroscopic axis complementary to a looping flow of content. The illustration in Figure 15 suggests one way that control may be educed along the stem of a systemic toroid.

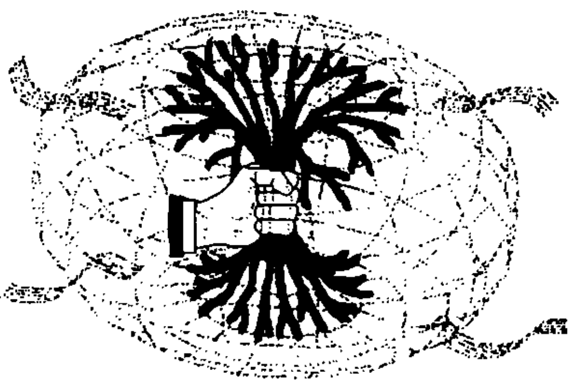

Figure 15

Visualizing as aspects of a systemic whole the complementary but non-exclusive concepts of **form**, **function**, **content**, and **control** — together with the **timing** of their dynamics — relative to an **environment** and relevant to a **percipient** leads us further toward a re-cognized appreciation of a cohesive systemological paradigm.

General Systemology

For the reasons outlined in the previous sections, it is a central tenet of systemology that the whole system is prior to any simplification or partitioning thereof, and furthermore that no *system* — properly so called — can be represented by any less a figure than a three dimensional, homeokinetic torus of circulations within a flux of throughputs. This suggests that the conceptual map for the organizing principles of systemology should itself be toroidal. Generalizing from the four primary systemological aspects, it is possible to reiterate the comprehensive definition for system and supplement it with an illustrative paradigmatic image (Figure 16) as follows:

At a given echelon of order, a *system* is a dynamic, organized, delimited, open, persistent, composite whole. It is volutionary, comprised of at least one loop and at least one link which manifest the aspects of **content**, **form**, **function**, and **control**, together with **timing** and **scaling** factors, relative to an **environment** and relevant to a **percipient**.

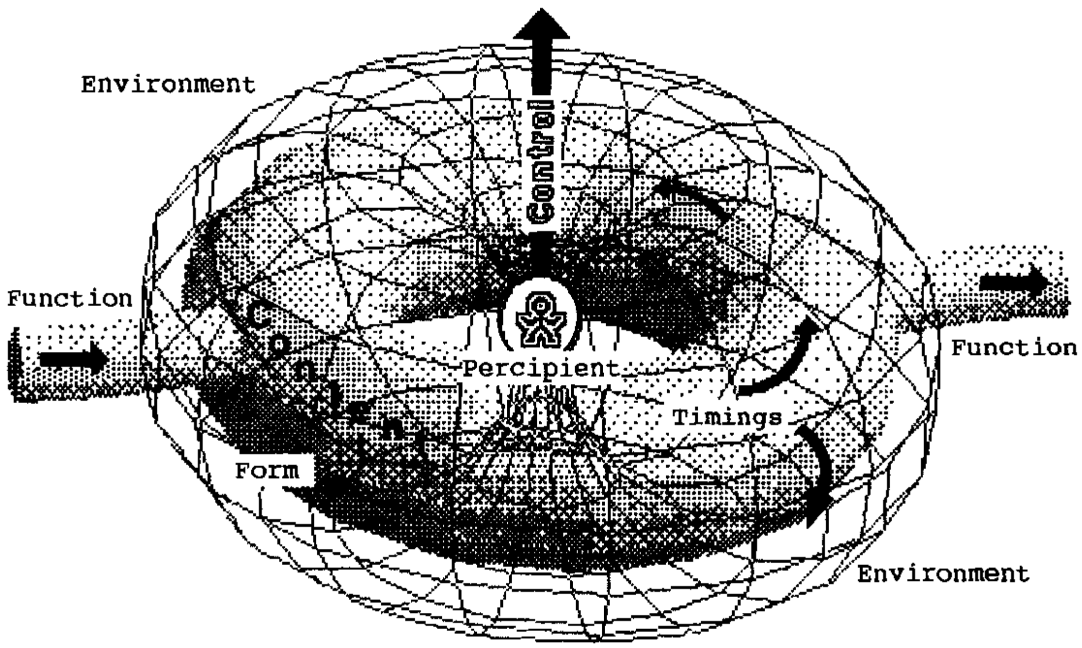

Figure 16

The paradigm illustrated as in Figure 16 offers an organized, constitutive core of systemological concepts accessible "by inspection." Having placed the visualization of a systemological paradigm into a toroidal context, we can proceed to explicate related concepts such as boundaries, interfaces, stability, succession, trajectories, chirality, polarity, potential, reciprocity, complementarity, ordination, orientation, etc. At the same time, a frame of reference is established for systemic principles such as conservation, equipotency, requisite variety, parsimony, autopoiesis, and mutuality. From a constitutive core such as this, the body of systemological knowledge can be developed. Throughout all of this, the percipient remains pivotal because there is no *system* — properly construed — except as it is defined relevant to purposes. By attending to the toroidal whole, this systemological paradigm accommodates the "real" world which is assumed to exist regardless of what any percipient may think as well as the "imaginary" world out of which come the thoughts which define and alter reality.

Losses and Gains

The systemological paradigm above offers a conceptual tool for apprehending the world whole. To obtain a secure grasp on a systemological paradigm, a percipient must first let go of false idealizations, in particular those which result from the reification of highly reduced concepts such as dimensionless points and perfect planes and straight lines and linear dependencies and "independent objects." These convenient approximations and assumptions which make calculations possible must not be misconstrued as the ideal forms toward which nature tends. In nature — and in systemology — an ideal tree is not a branching stick assembled of straight lines with spherical fruit as sketched in Figure 17 but rather is a comprehensive toroidal fluxion whose fruit may have a toroidal form (around a core) also, as sketched in Figure 18. Mis-identification of systems with "sets" must give way to definitions of systems as inclusive homeokineses amidst flux. Control is no longer merely to be seen as an exertion of force but rather as a continual re-ordering of activity with reference to ends [9]. "Independent" encapsulations must be supplanted by ineluctable connectivities. Determination by initial conditions must be balanced by apprehensions of equifinality. And so on and on.

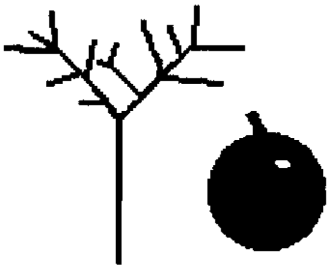

Figure 17

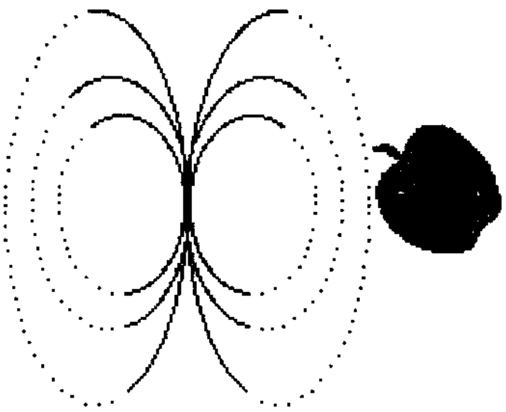

Figure 18

Clearly, a systemological paradigm turns many a conventional worldview inside-out. To adopt and assimilate it is to re-cognize the world from the linear, the convex, the closed, the cropped, and the particulate such as indicated by Figure 19

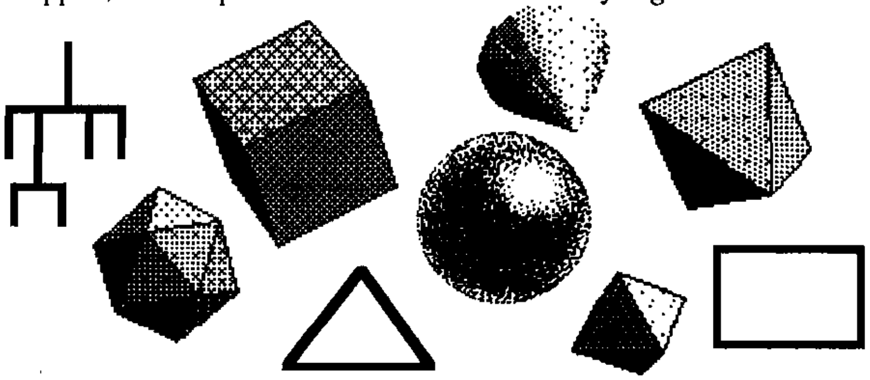

Figure 19

into the cyclical, the hyperbolic, the open, the continuous, and the vorticulate such as suggested by Figure 20.

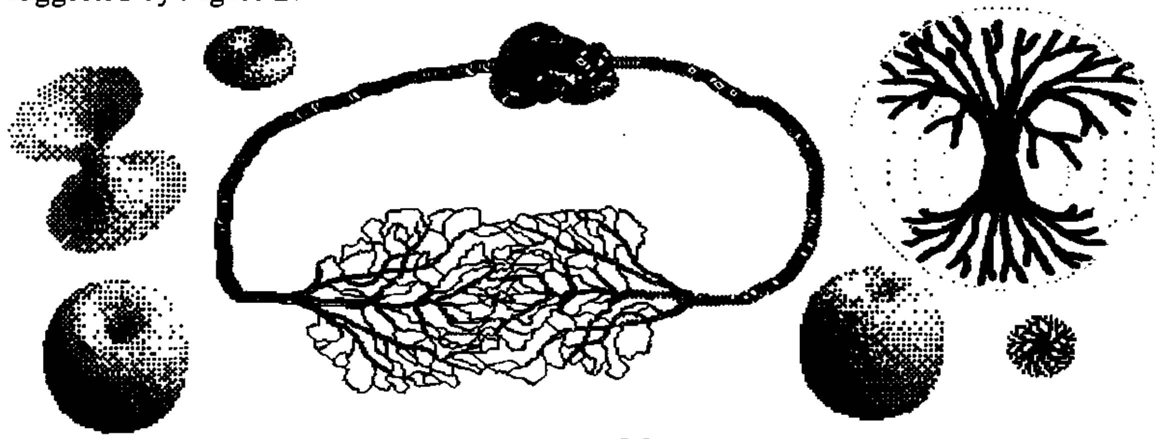

Figure 20

Even as systemology challenges cherished beliefs, it returns dividends many-fold. A systemological paradigm having a toroidal topology is substantially more comprehensive than any cropping, part or piece can be, and it is much more general than any conceptual mapping comprised of disjoint "objects." It is simple enough to visualize, complex enough to establish a constitutive core, appropriate to those phenomena most readily identified as systems, and adequate to accommodate a general theory. It conforms to the contours of theoretical systems such as the attractors and repellors of mathematical dynamics, as well as to the contours of natural systems such as those of trees, animals, magnets, and weather. Toroids map conceptual space into comprehensible orders without resorting to artificial linear dichotomies or rigid arrays of pigeon holes. The paradigm informs a percipient as to how to recognize what is a system and how to distinguish its functional, formal, content, and control aspects, each in the context of timing, scaling, environment, and one another. It can provide a dependable way to associate cases with principles by demonstrating the continuum between particulars at the periphery and generalities near the core. It teaches percipients to look beyond "issues" to understand tributaries and anticipate consequences. Perhaps most importantly, the systemological paradigm legitimizes purposeful activity with respect for the percipient who ultimately defines and exerts control over what is THE SYSTEM of concern.

A Different Frame of Mind

As compared to conventional worldviews in mathematics, the sciences, and even in "systems thinking," systemology is a different enough "cognology" to be a "re-cognology." Although systemology is a logical and abstractive discipline centered upon a particular rationality of a toroidal paradigm, it shares with the arts a sense of aesthetic appreciation, kinesthetic dynamics, and universality of meaning. In so doing, it affords to us a fluid and harmonious alternative to rigid mechanical metaphors.

On a conceptual level, systemology reconciles many paradoxes. It sets forth a frame of reference which respects function, form, content, and control as co-constituents. It suggests that alleged dualities, such as that between "waves" and "particles," might dissolve in a flux of toroidal "vorticles." It shows how transformation and organization are mutually complementary, how deviations make control possible. It offers a context for general principles such as "requisite variety," "conservation," and "equifinality." It provides at last a constitutive definition for *system*. It even helps to identify *purposes* as "imaginary attractors" in a topology of toroidal centers with multifarious paths among them as suggested by the illustration in Figure 21 in which a percipient rejects home, love, and lucre for the purpose of becoming a star.

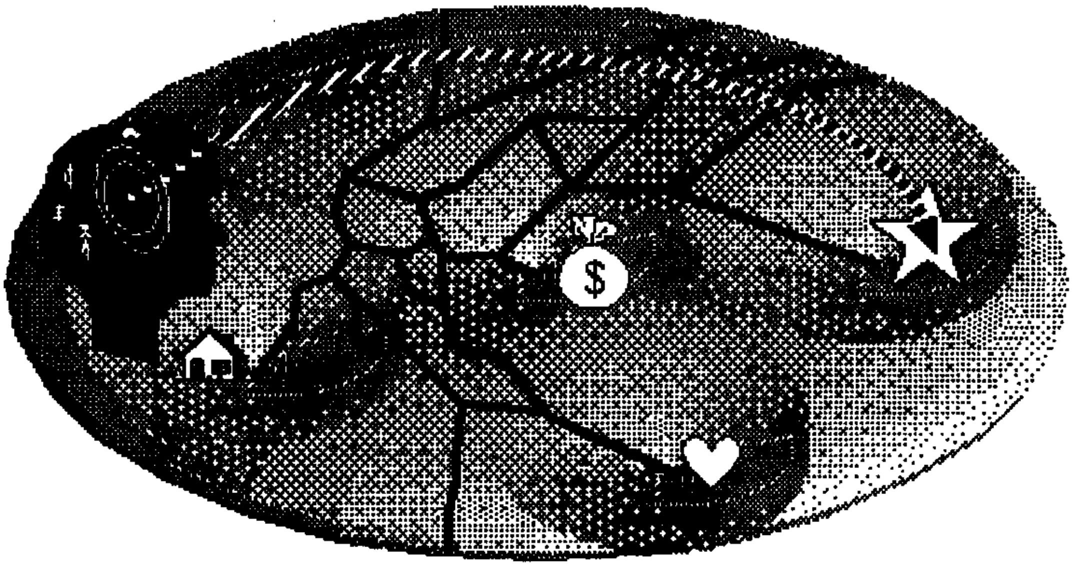

Figure 21

At the same time, systemology challenges many a cherished belief, e.g., Platonic idealism, scientific objectivity, analytical determinism, and "problem-solving." It turns inside-out the image of a universal billiard game of colliding particles. It supplants notions of "hierarchy" with an appreciation of heterarchies. It suggests that nature abhors a lode as well as a vacuum. It teaches that a system understood as a whole is less than the sum of its parts. Most of all, it legitimizes imagination as a co-creative co-respondent with reality.

Systemologically, a system itself — defined by a percipient for a purpose — is taken as whole and prior to any partitioning. It has a toroidal continuity and orientation, at once closed in a loop and open to a flux of throughput. It has a tributary history and a consequential future. It has a life-span from its development through a sustained operational stage, ending with decline and disintegration. A system may be as simple and consubstantial as a circulating convection or as elaborate as a society of living creatures. It is mutually interdependent and co-evolutionary with its environment.

Because it acknowledges and legitimizes the role of purposeful percipients, the systemological paradigm may be viewed as "subjective," prejudiced and political, just as the various popular paradigms are. It is, however, much more general and substantially richer in its implications than those others, and its veracity is open to checking by anyone who has a mind to. Since the notion of system entails the notion of a purposeful definition, its paradigm does not pretend to being exclusively "objective," but rather it is forthright in showing where preferentiality is manifest. It is not afraid to ask WHY, i.e., for what purpose, admitting that every *system* — properly so-called — is intrinsically social because it is at once a perception of reality, a matter of definition, and a subject of discourse. Insofar as percipients define their systemic worldviews clearly, then communicate honestly about them, the truth which they make among themselves can become more readily available for all to see.

One superficial conclusion about the "politics" of systemology might be that it is inherently prejudiced toward a so-called "environmental" viewpoint. It is true that systemology would attend to the big picture, even to the extent of corroborating a Gaia hypothesis, but it would not say that such agendas as "preserving bio-diversity" or "preventing global warming" are inherently "good." Instead, it would provide the conceptual tools for understanding the systemic tributaries and appreciating the systemic consequences of taking one or another course of action. If, for example, an "ozone hole" is a preferred outcome, systemology can help to make it happen. What systemology would never do is to accept a short, narrow, local, cropped or compartmentalized view of any phenomenon. And it would always re-mind us that there can be no viable system without a viable environment [12].

It is by attending to tributaries and to consequences — beyond the immediate "issues" — that systemology can help to inform consciences. It tells us that history matters and that purposes projected into the future do too. It shows how renditions as well as designs determine viability, how toroidal cycles may either sustain or destroy. It reminds us that we all are "downstream" as accountable recipients at the same time that we all are "upstream" as responsible agents in a fluxion of systemic loops and links. It argues that if we do not like what is happening, we may find that the enemy is, most likely, within ourselves.

Accommodations

There is no question that a systemological paradigm cast in a toroidal image re-frames the art and the science of learning for anyone who was indoctrinated in conventional technocratic or popular cultures. What might it do to offer a perspective of the arts and the sciences themselves?

Sciences strive to tell us how things are, regardless of what people think about the world; arts express what might be, given that people are feeling and thinking and planning and designing. Sciences strive for formal generality which has applicable to particulars; arts offer particular intimations of general forms and meanings. Sciences achieve their most reproducible results "close to equilibrium," i.e., where there is a very strong probability that a given action will produce a predictable outcome; arts operate "far from equilibrium," i.e., where there are many possible ways to produce a desired outcome from a given initial situation.

In the context of a simple toroidal whole, the center is the region closest to equilibrium in the sense that the meridial as well as the annular fluxes are most concentrated there, much as a whirlpool captures and holds what would otherwise drift along in a stream. The periphery of the toroid is farthest from equilibrium, with relatively diffuse currents and cross-currents over relatively broad surfaces. The center can thus be considered to be most general and the periphery most particular in the big picture of a toroidal whole. This rationale suggests that systemicity establishes a stem of the most general principles and paradigms from which sciences branch outward through the particulars of arts and applications, thence back around into rooting philosophies which confirm systemicities. The counterflow of ideas from philosophies and arts back into sciences is an equally legitimate and sustaining dynamic. Throughout, arts and applications intermingle around the periphery. Thus in the mutual interactions suggested by the sketch in Figure 22, we see a hint of the tightly integrated yet richly diverse whole of human endeavors.

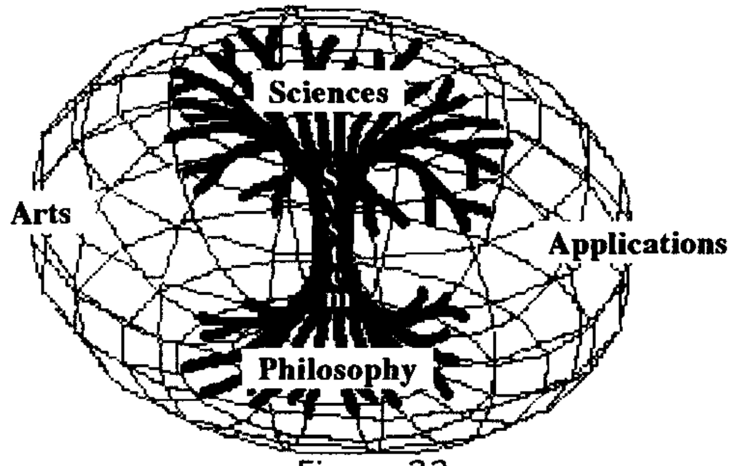

Figure 22

Conclusion

It is the main article of a faith in general systems thinking that there is an order which embraces the orderings of particular systems [11]. Can an abstract paradigm of toroidal systemicity confirm this faith and supplant the expedient "realities" of "games," "problem-solving," and other business-as-usual? Can it legitimize our artfulness? Indeed, should it? I submit that our well-being in harmony and rhythm with one another in our environment vitally depends upon our apperception of the art and the science of systems. The applied philosophy of a General Systemology re-minds us to re-cognize the ineluctable dynamics, the intrinsic linkages, and the inevitable continuities among all things. If, after all, there is nothing so practical as a good theory, systemology should help us to improve our designs and our renditions. By letting go the linear, choppy, cropped, under-dimensioned, and short-sighted paradigms which threaten our integrities, we could have the means to apprehend the consequences of our actions in good conscience and the opportunity to adopt wholesome attitudes so as to appreciate ourselves and our habitats in full respect.

[illegible]

References

[1] Ackoff, R.L., and F.E. Emery, On Purposeful Systems. Chicago: Aldine-Atherton, 1972.

[2] Ashby, W. Ross, An Introduction to Cybernetics. New York: John Wiley & Sons, 1966.

[3] Ashby, W. Ross, "Principles of the Self-Organizing System," from Principles of Self-Organization, H. von Foerster and G.W. Zopf (eds). New York: Pergamon Press, 1962.

[4] Bunge, Mario, "The GST Challenge to the Classical Philosophies of Science," from International Journal of General Systems 4, 29. Gordon and Breach Science Publishers, Ltd., 1977.

[5] Edelman, Gerald M., Bright Air, Brilliant Fire. New York: BasicBooks, 1992.

[6] Hall, Arthur D., A Methodology for Systems Engineering. Princeton: D. Van Nostrand Co., 1962.

[7] Klir, George J., Facets of Systems Science. New York: Plenum Press, 1991.

[8] McCulloch, Warren S., Embodiments of Mind. Cambridge: MIT Press, 1965.

[9] McNeil, Donald H. Systemology, The Fundamentals of a General Science of Systems. Masters Thesis in Social Systems Sciences, Philadelphia: Wharton School, University of Pennsylvania, 1981.

[10] von Bertalanffy, Ludwig, General System Theory. New York: George Braziller, 1968.

[11] Weinberg, Gerald M., An Introduction to General Systems Thinking. New York: John Wiley, 1975.

[12] Wilden, Anthony, System and Structure (Second Edition). New York: Tavistock Publications/Methuen, 1980.

[13] Young, Arthur M., The Geometry of Meaning and The Reflexive Universe. New York: Delacorte Press, 1976.