A Tutorial in Autopoiesis

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(adapted from the web site at http://www.enolagaia.com/Tutorial1.html)

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This introductory orientation

...is designed to provide you some general context regarding how *autopoietic theory* originated, how it developed, and where it stands now. Autopoietic theory is the term I use to denote the work of Chilean biologists Humberto R. Maturana and Francisco J. Varela (originally labeled *the biology of cognition*).

Background: Biology of Cognition / Autopoietic Theory

This initial section is designed to orient you in preparation for the remainder of the Tutorial.

- It will present some of the key observations and issues which led to the creation of the biology of cognition / autopoietic theory.
- These in turn describe some important aspects of the perspective from which this work has proceeded.
- This section ends with a very brief description of the theory's merits and the fields within which it has been applied to date.
- You can then proceed to an introduction to the theory itself.

There is an essential circularity in living systems.

- Living systems exhibit a sort of circularity in their form and structure. This is evident when we examine the way organisms are constituted by their components. These components are interconnected so as to make up a single whole structure. No single component is either a starting or ending point for this set of structural connections, because this set cannot be reasonably described as a linear series of dependencies. Instead, it is a web of interdependencies in which each component is mutually dependent on all the others in 'adding up' to the entirety of a viable structure. If you were to start with any given component and trace its structural dependencies on neighboring components, then trace the dependencies of those neighbors to their neighbors, etc., you would eventually come back to the first component as something upon which one or more other components are themselves reliant. Because this brings you back to the original point, the structure evidences 'circularity' with respect to its structural constitution.

- Living systems are not just static structures. We ascribe 'life' to them because they're dynamic. We can find another sort of circularity in their internal operations. These internal operations are 'circularly' interconnected in the same sense that the components are. There is something about the identity and unity of a living system which is maintained by these internal operations -- something which can be influenced by events in the living system's environment, but which is specific to the living system itself. You can move the living system to another environment, but (so long as it can successfully survive) this circularly-interconnected network of internal operations will persist. These operations evidences no intrinsic 'purpose' beyond maintenance of

the living system's constitutional and configurational integrity.

There is an essential circularity in a living system's experience.

- The course of actions ('responses') observed for a given living system exhibits a sort of circularity in the sense it is (at least partially) repetitive. The exact trajectory of these courses of action is mediated 'internally' by the organism's capacities for action. In other words, what the organism *will* do (and remain living) will be circumscribed by the range of things the organism *can* do. Because these capacities are in turn qualified by the living system's circularities of form, configuration and internal operations, similar circumstances will result in similar actions.

- Correspondingly, the course of situational transitions affecting the organism ('stimuli') is mediated 'externally' by those potentials the world affords. Even though it is the organism's own configuration which determines its capacities for action (and hence its specific actions), the 'environment' influences the overall course or trajectory of the situations encountered, and hence the series of resulting actions. As such, there is a 'circularity' in the reciprocal interplay between the living system and its 'environment'.

- The 'circle' of this interplay cannot be reasonably said to have a starting point (except the point at which the living system originates). It cannot be said to have an ending point (except the point at which the living system ceases to be living). As such, we cannot predict the living system's course of activities based on 'first' or 'last' causes.

- Because of this, the course or trajectory of reciprocal engagement between a living system and its observed 'environment' is not reducible to exclusive determination by one or the other.

There is an essential circularity entailed in exploring 'cognition'.

- There is no approach to exploring or explaining cognition which does not entail and employ the very faculties being explored and explained. We are living systems, and we exhibit 'cognition'. There is no way for us to address, much less explain, our cognitive abilities without employing those same cognitive abilities.

- To date, the primary response to this paradox has been to ignore it and proceed with respect to a presumably fixed fundament (a frame of reference taken as a 'given') external to our act(s) of cognition. Once such a fundament has been specified, all explanations are framed in terms of linear cause-and-effect. Phrased another way, conventional enquiry obscures or denies the essentially circular character of living and cognizing by attempting to treat the phenomena as something which can be 'laid out in a straight line' of explanatory constructs.

- Where the presumptive fundament is 'objective reality' (i.e., the world as it is presumed to obviously be), the mediation between situation and action is explained in terms of ordered inference with respect to a model of that reality. The typical approach employed in devising such models is reduction of the subject phenomenon into atomic objects (components, constructs, etc.) from whose character everything can be explained.

- Although it seems effective in (e.g.) physics, this approach breaks down when confronted with

the tacit, extralinguistic, emotive, and/or intuitive character of that which we humans seem to do.

- The objectivistic basis for this conventional approach is further disputed by recent trends toward (a) more commonly seeing ourselves operating in multiple 'worlds' (particularly social ones) and (b) increasingly acknowledging the degree to which each of these 'worlds' is molded by contextual and conceptual factors intertwined with the very act of engaging it.

How can we address circularity without 'circular reasoning'?

- In recent decades, there have been a number of attempts to devise 'holistic' or 'systemic' frameworks addressing our nature from a perspective more useful than that of objectivism.

- This is a difficult pursuit. Once a presumed (and presumably knowable) 'real world' ceases to serve as a fixed (and presumably known) base from which to build, the comfortably linear progression of conventional explanations is less obtainable.

- The farther one gets from explanatory reliance on atomic 'objects', the less able one is to link explanations with discrete elements and pursue proof through experimental demonstration or rigorous inferential means.

- As a result, alternative theories must often be judged with respect to their overall explanatory coherence. Unless they can be grounded in demonstrable facts, such theories run the risk of being seen as 'circular' in the negative sense of 'deducing X from a presumption of X itself'.

The Answer: By employing a rigorous framework addressing these essential circularities.

- There is one such 'systemic' framework addressing living systems, their phenomenology, and their cognition in terms of these essential circularities.

- This framework -- originally labeled *the biology of cognition* -- originated over three decades ago with Chilean biologist Humberto Maturana. His 1969 paper 'Neurophysiology of cognition' (Maturana, 1970) first presented these ideas in English.

- During the 1970's Maturana, often in conjunction with his student Francisco Varela, published a series of papers in which this framework was progressively refined. By the mid-1970's, Varela began exploring selected themes on his own, but staying within the original explanatory lexicon and conceptual framework.

- The body of conceptual work that has accumulated over the subsequent years -- termed *autopoietic theory* -- is the focal subject of this Website.

- Autopoietic theory directly addresses and successfully analyzes the basic configural and operational circularities of living systems.

- The theory's foundations are laid out in detail, and their consequences are delineated with

considerable care.

- The theory has been invoked and applied in diverse fields including immunology, psychology, management science, human-computer interaction, family therapy, sociology, economics, postmodern philosophy, and public administration.

- Building upon themes from biology of cognition / autopoietic theory, Varela has recently outlined an alternative to prevailing cognitivistic and connectionist models of cognition -- an *enactive cognitive science*.

- The consequences of autopoiesis and enaction thematically parallel the foci of other current analyses of humans and their activities in terms of (e.g.) systemics, complexity, and subjective experience.

- Unlike some of these other approaches, autopoietic theory obtains focus on the only element common to the range of such topics -- the human herself, operating as an observer.

- It accomplishes this by shifting explanatory focus from atomic units in an objective world to essential relations among processes operating 'circularly' to constitute the organism as a living system and the observer as a cognitive organism.

As a consequence, the essential circularities noted above are neither neglected nor avoided as paradoxes.

- Instead, they are embraced in the form of two maxims:
  "Everything said is said by an observer."

The qualification of all 'knowledge' with respect to a given observer is both the epistemological foundation and the explanatory focus of autopoietic theory.

"All knowing is doing, and all doing is knowing."

The observer's 'cognition' is a process involving the entirety of her interactivity, not just abstract mentation. As such, cognition cannot be segregated from praxis.

This completes your background orientation to the issues and themes which form the basis for the biology of cognition / autopoietic theory.
If you wish to learn more, the next step is an introduction to the theory itself.
To obtain this introduction, continue scrolling down this page...

Maturana and Varela

Humberto R. Maturana

Humberto R. Maturana originally studied medicine at the University of Chile and biology with J.Z. Young at Oxford before carrying out pioneering work on neurophysiology at Harvard during Ph.D. and post-doctoral studies. In the early 1960's at MIT, his research led to a landmark paper, "What the Frog's Eye Tells the Frog's Brain", which established a novel perspective on the interplay between cognition and neurophysiology.

As the 1960's progressed, Maturana began to critically question the prevailing notions of cognition. The further he proceeded, the more he realized he would have to completely redefine the phenomenology of the living in terms of the organism itself, so as to avoid superfluous and confusing abstractions. This in turn forced him to define living systems.

His 1970 paper "Neurophysiology of Cognition" was the seminal presentation of his novel approach in which living systems are defined systemically in terms of their processual configuration. This served as the launching point for subsequent creation and elaboration of his theories, for which he uses the label "*the biology of cognition*":

> Professor Maturana has held visiting appointments and given lectures throughout the world. He is currently a professor at:
>
> F. Ciencias Dpto. Biologia
> University Of Chile
> Casilla 653 Santiago Chile

"The Biology of Cognition is an explanatory proposition that attempts to show how human cognitive processes arise from the operation of human beings as living systems. As such, The Biology of Cognition entails reflexions oriented to understand living systems, their evolutionary history, language as a biological phenomenon, the nature of explanations, and the origin of humanness. As a reflection on how we do what we do as observers it is a study in the epistemology of knowledge. But, and at the same time as a reflection on how we exist in language as languaging beings, it is a study on human relations."

Humberto Maturana

Francisco J. Varela
(1946-2001) Francisco J. Varela was a student and colleague of Maturana's. He originally studied with Maturana in Chile and then worked on mathematical biology with Heinz von Foerster at the University of Illinois and cybernetics at the University of Colorado.

During his student period, Varela served as a frequent co-author of the papers that transformed Professor Maturana's original vision into a theoretical framework with a specific lexicon. This framework claimed the essential feature of living systems was *autopoiesis* -- a system's self-production of the components realizing its *organization* (its definitive processual configuration).

A living system is any system exhibiting autopoiesis in the physical space.

Most recently, Varela was the Director of Research at CNRS (National Institute for Scientific Research) at the laboratory of Cognitive Neurosciences and Brain Imaging (LENA) located at the Salpêtrière University Hospital in Paris. He served as the head of the Neurodynamics Group and a member of the Senior Faculty at CREA, Ecole Polytechnique.

Sadly, Francisco died on May 28, 2001, at the age of 54.

- **Focus File on Francisco Varela**

Through the early 1970's, the theory was extended and refined in a series of papers by Maturana, often co-authored with Varela.

Two of the key articles ('Biology of Cognition' [Maturana, 1970] and 'Autopoiesis: The Organization of the Living' [Maturana & Varela, 1973]) were reprinted together in a 1980 volume entitled *Autopoiesis and Cognition: The Realization of the Living*.

In the mean time, Varela had published a 1979 volume entitled *Principles of Biological Autonomy*, which extended the scope and depth of the earlier papers.

These two books are the cornerstones of the theoretical literature in this field.

During the 1980's, Maturana and Varela collaborated to produce *The Tree of Knowledge* -- an overview of their ideas for general consumption. This book has served to introduce a wide (and growing) audience to their work.

Most recently, Varela (in collaboration with Evan Thompson and Eleanor Rosch) has outlined an agenda for an *enactive cognitive science* in the 1991 book *The Embodied Mind*. The subject of enaction will be discussed later in Tutorial 2.

Cognition as a Biological Phenomenon

"Cognition is a biological phenomenon and can only be understood as such; any epistemological insight into the domain of knowledge requires this understanding."

(Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 7)

Maturana's early experimental work in neurophysiology and perception (Maturana et.al., 1960; Maturana et.al., 1968) led him to question information-theoretic notions of cognition.

The theory he subsequently created was originally intended to address issues theretofore subsumed under studies of 'cognition' and/or 'perception'.

The theory's scope has not remained limited to those issues. It builds from its cognitive base to generate implications for (among other things) epistemology, communication and social systems theory. These additional foci have traditionally been placed under the jurisdictions of (respectively) philosophy, linguistics, and sociology.

Why, then, should we consider them a subject of concern for a biologist? Because in all these areas, we are exploring phenomena which are manifested by, or mediated through, individual biological entities. As a biological phenomenon, cognition is viewed with respect to the organism(s) whose conduct realizes that phenomenon. In autopoietic theory, cognition is a consequence of circularity and complexity in the form of any system whose behavior includes maintenance of that selfsame form.

This shifts the focus from discernment of active agencies and replicable actions through which a given process ('cognition') is conducted (the viewpoint of cognitive science) to the discernment of those features of an organism's form which determine its engagement with its milieu.

This orientation led to a systematic description of organisms as self-producing units in the physical space.

The principles and definitions making up this systematic schema will be termed autopoietic theory's **formal aspects**.

Deriving from this formal foundation a set of operational characteristics (e.g., self-regulation; self-reference), Maturana, and later Varela, developed and extended a systemic explanation of cognition and a descriptive phenomenology.

The principles and definitions making up this systemic description will be termed autopoietic theory's **phenomenological aspects**.

Autopoietic theory has been applied in diverse fields such as software engineering, artificial intelligence, sociology, and psychotherapy.

Fundamental Referential Contexts: Domains and Spaces

Domains

A *domain* is a description for the 'world brought forth' -- a circumscription of experiential flux via reference to current states and possible trajectories.

Perhaps the most important descriptive concept in both Maturana's and Varela's writings is **domain**. The term generally connotes a 'realm' or 'sphere' circumscribing:

1. the relations among observed systems and the unities (medium) with which they can be observed to engage (e.g., phenomenological domain) or

2. the foregoing plus all potential states of relation and/or activity among the given unities (e.g., domain of interactions).

Perhaps the best way to understand the usage and importance of the 'domain' within autopoietic theory is to review the multiple domains identified or defined in the literature. Maturana and/or Varela defined a number of domains in developing autopoietic theory's formal aspects into a phenomenological framework. These include:

Domain of interactions

"...the set of all interactions into which an entity can enter..." (Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 8).

Domain of relations

"...the set of all relations (interactions through the observer) in which an entity can be observed..." (*Ibid.*).

Phenomenological domain

That set of actions and interactions "...defined by the properties of the unity or unities that constitute it, either singly or collectively through their transformations or interactions."(Varela, 1979, p. 46).

Cognitive domain

the set of "... all the interactions in which an autopoietic system can enter without loss of identity..." (Maturana & Varela, 1980, p. 136) An observer's cognitive domain circumscribes "...all the descriptions which it can possibly make." (*Op. cit.*, p. 119).

Consensual domain

".. a domain of interlocked (intercalated and mutually triggering) sequences of states, established and determined through ontogenic interactions between structurally plastic state-determined systems." (Maturana, 1975, p. 316)

Linguistic domain

"...a consensual domain of communicative interactions in which the behaviorally coupled organisms orient each other with modes of behavior whose internal determination has become specified during their coupled ontogenies." (Maturana & Varela, 1980, p. 120)

The notion of 'domain' is particularly useful in addressing actual systems (e.g., enterprises). By identifying, delineating, and sorting out the relevant domains in which enterprises (and their subcomponents) operate, analysis and planning are greatly facilitated.

Spaces

"Space is the domain of all the possible interactions of a collection of unities (simple, or composite that interact as unities) that the properties of these unities establish by specifying its dimensions. It can be said, of a composite unity on the one hand, that it exists in the space that its components specify as unities because it interacts through the properties of its components, and, on the other hand, that it is realized as a unity in the space that its properties as a simple unity specify. Once a unity is defined, a space is specified."

(Maturana, 1978, p. 33)

The term **space** is typically reserved for the context in which unities are delineated -- a static referential background within which systems are defined.

The only specific 'space' included in basic autopoietic theory is the **physical space** -- i.e., the world of matter and energy addressed by (e.g.) physical sciences. Both Maturana (e.g, 1978a) and Varela (1979) make allowance for other spaces in which unities can be discerned, but neither has explicitly delineated examples of autopoiesis in other spaces.

Fundamental System Description: Unities

A unity is...

"That which is distinguishable from a background, the sole condition necessary for existence in a given domain. The nature of a unity and the domain in which the unity exists are specified by the process of its distinction and determination; this is so regardless of whether this process is conceptual or physical."

(Maturana & Varela, 1980, p. 138)

"...[A]n entity, concrete or conceptual, dynamic or static, specified by operations of distinction that delimit it from a background and characterized by the properties that the operations of distinction assign to it."

(Maturana, 1978, pp. 31-32)

It is important to understand that autopoietic theory addresses systems, and that these systems are to be addressed with respect to the observer observing them. In accordance with this observer-centric approach, Maturana and Varela define a 'unity' to be the most elementary object of perceptual / cognitive reference. They then lay the basis for addressing systems (comprised of multiple discernible elements) by distinguishing between two types of unities -- **simple unities** and **composite unities**.

"We distinguish a simple unity as an entity in which we do not distinguish components, and which is, thus, characterized only by the properties with which it appears endowed by the

operation of distinction that brings it forth.

We distinguish a composite unity as a continuum in which we perform further operations of distinction, and bring forth additional unities that are specified as a components in relation to the simple unity that they integrate as a continuum prior to its decomposition. Therefore, a component exists as such only in relation to the composite unity that it contributes to constitute (integrate) as a unity that can be distinguished as a simple unity (a continuum) of a particular kind."

Maturana (1983), p. 257, vertical spacing added for readability)

Because this account of unities is based on the observer's operations in distinguishing them, it follows that the observer's engagement with a system seen as a simple unity (as a unit whole) is different from her engagement with the system seen as a set of constituent elements. The observer brings forth from the ambience a unity, which she can address as either simple (i.e., a unary whole) or composite (a set of components).

The use of the word "either" is deliberate, because the observer cannot address a unity as both simple and composite at one time. The phenomenological domains in which the unary whole and the components are realized (as observable entities via engagement with the observer) are distinct. Any intersection between these domains lies wholly with or through the observer. Naively construing these distinct domains as identical can lead to potentially anomalous or erroneous descriptions and explanations.

There is an old saying in cybernetics and systems theory that for a system "the whole is more than the sum of its parts." The above-cited points explain why such an apparent disjunction should be apparent. An observer observing the set of constituent elements comprising a composite unity can see "the sum of the parts", while the "whole that is more" can only be seen if that observer shifts to addressing the system as a unit whole (simple unity).

This can be illustrated in more detail. Varela (1979) distinguishes between two viewpoints one can take on a composite unity. The first (the *behavioral view*) addresses the composite unity as a simple unity (i.e., as a whole). The second (the *recursive view*) addresses the composite unity in terms of its participating components.

Each of these two perspectives Varela labels a *cognitive point of view (CPOV)*. A cognitive point of view specifies the distinctions, indications, and basic stance via which an observer engages a particular unity.

I have prepared a more detailed presentation illustrating the CPOV as well as the behavioral and recursive views.

This presentation is available at the Inside versus Outside Focus File page here at *The Observer Web*. http://www.enolagaia.com/UnityInOut.html

For the purposes of this tutorial, this is sufficient to give you some basic orientation to unities and the distinctions an observer must face when engaging a system as either a simple or a composite unity.

Now let's turn our attention to the two essential attributes of a composite unity...

Fundamental System Attributes: Organization and Structure

Organization

"The relations that define a machine as a unity, and determine the dynamics of interactions and transformations which it may undergo as such a unity, constitute the organization of the machine."

(Maturana & Varela, 1980, p. 77)

Systems cannot be defined by simply enumerating or tracing the layout of their constituent elements. The definitive attribute of a systemic entity is the set of inter-component relationships which:

1. outline its form at any given moment and

2. serve as the core 'identity' which is maintained in spite of dynamic changes over time.

In autopoietic theory, this set of defining relationships is termed a system's **organization**.

Maturana (1975) notes 'organization' comes from the Greek and means 'instrument'. By using this word for the essential, defining character of a system he focuses attention on "...the instrumental participation of the components in the constitution of the unity." (*Op. cit.*, p. 315)

A system's organization defines its identity, its properties as a unity, and the frame within which it must be addressed as a unary whole.

Structure

"In a composite unity, be this static or dynamic, the actual components plus the actual relations that take place between them while realizing it as a particular composite unity characterized by a particular organization, constitute its structure.

In other words, the structure of a particular composite unity is the manner in which it is actually made by actual static or dynamic components and relations in a particular space, and a particular composite unity conserves its class identity only as long as its structure realizes in it the organization that defines its class identity."

(Maturana, 1988b, 6.iv.)

In effect, a system's organization specifies a category, within which there may be many specifically-realized instantiations. Specific systemic entities exhibit more than just the general pattern of their organization -- they consist of particular components and relations among them.

A systemic unity's organization is specifically realized through the presence and interplay of components in a given space. These comprise the unity's **structure**. Maturana (1975) points out the word 'structure' comes from the Latin meaning 'to build'. He employs this allusion in assigning to this

label "...the actual components and ... the actual relations which these must satisfy in their participation in the constitution of a given unity." (*Op. cit.*, pp. 315-316) Structure does not determine the overall character of a unity; it determines only "...the space in which it exists and can be perturbed." (*Ibid.*)

A unity may change structure without loss of identity, so long as its organization is maintained. Maturana and Varela's distinction between organization and structure provides a basis for sorting out descriptions of systems into their abstract and concrete aspects. Formally speaking:

> "The organization of a machine (or system) does not specify the properties of the components which realize the machine as a concrete system, it only specifies the relations which these must generate to constitute the machine or system as a unity. Therefore, the organization of a machine is independent of the properties of its components which can be any, and a given machine can be realized in many different manners by many different kinds of components. In other words, although a given machine can be realized by many different structures, for it to constitute a concrete entity in a given space its actual components must be defined in that space, and have the properties which allow them to generate the relations which define it."
> (Maturana & Varela, 1980, p. 77)

Illustrative Examples

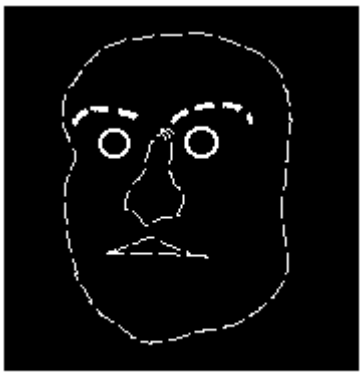
A 'nitty-gritty' illustration of the distinction is given in the 1987 book *The Tree of Knowledge*:

> "...in a toilet the organization of the system of water-level regulation consists in the relations between an apparatus capable of detecting the water level and another apparatus capable of stopping the inflow of water. The toilet unit embodies a mixed system of plastic and metal comprising a float and a bypass valve. This specific structure, however, could be modified by replacing the plastic with wood, without changing the fact that there would still be a toilet organization."
> (Maturana & Varela, 1987, p. 47)

The organization / structure dichotomy is graphically illustrated in the work of the 16th Century Italian painter Giuseppe Arcimboldo, who devised remarkable portraits in which the faces are composed of (e.g.) fruits, vegetables, seafood, etc. His fanciful art realized a discernible facial 'organization' through a 'structure' of novel components. Below is his portrait (of Emperor Rudolph II) entitled *Vertumnus*.

Now here's the point...

How do you recognize this pile of fruits and vegetables (the structure) as a face? Because of its essential organization, which is illustrated below as a schematic pattern.



Organization: A Face

In other words, the schematic is a simple analogy for the 'organization' of a face. We can recognize this 'organization' (as a face, in this case) even though Arcimboldo has instantiated or realized it with a novel 'structure' (i.e., fruits and vegetables, rather than flesh).

The complementary distinction between organization and structure is very useful in delineating and analyzing systems' form and function -- for example, describing enterprises as having generally invariant form in spite of specifically changing components.

The Observer

"Anything said is said by an observer."

(Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 8)

Up to this point in the Tutorial, we have been using the term 'observer' in the colloquial sense of 'one who observes'. The biology of cognition / autopoietic theory was developed to explain how it is that the observer observes. Because of this, the theory offers a specific analysis of what constitutes an observer. This analysis is framed with regard to the constitution of the observer as a biological system.

Maturana's initial work on cognition emphasized individual living systems. As a result, autopoietic theory has as its foundation the manner in which living systems address and engage the domain(s) in which they operate. This orientation subsumes the manner in which autopoietic theory addresses itself (as a scientific theory) and all other phenomena.

A key observation in Maturana's early work is that the nervous system is **'operationally closed'** (i.e., its transformations occur within its bounds). Ongoing behaviors, which to an observer seem linked to the external "world", are enacted solely with regard to the closed state of the nervous system. Any reference to entities in the environment is indirect, because a cognizing system engages the 'world' only in terms of the perturbations in its nervous system.

To the extent that the nervous system recursively interconnects its components (as in our brains), the organism is capable of generating, maintaining and re-engaging its own states as if they were literal re-presentations of external phenomena. Such states are 'second-order' in the sense that they are derivative from, rather than literal recordings of, experience.

These states are called **descriptions** in autopoietic theory, and an organism operating within the realm of its descriptions is an **observer**.

The combination of the nervous system's operational closure and the notion of descriptions imposes a character of distance or artificiality to the means by which observers can reflect upon, or interact with each other about, their environment. With regard to individual reflection, this implies that cognitive systems engage only their descriptions -- hence always at least one step removed from the phenomena they may naively believe to be directly or objectively manifest. As such, engagement with the environment cannot be described as a process of 'information transfer' in the sense that the observer acquires or absorbs 'information' from outside.

These points describe the observer in terms of being a particular sort of system. The next step is to explore the operations of such a system which make it an observer (i.e., its 'observation').

"An observer is a ... living system who can make distinctions and specify that which he or she distinguishes as a unity, as an entity different from himself or herself that can be used for manipulations or descriptions in interactions with other observers."

(Maturana, 1978b, p. 31)

The fundamental operation in observing is that of **distinction** -- "...the pointing to a unity by performing an operation which defines its boundaries and separates it from a background." (Maturana, 1975, p. 325) Through the recursive distinguishing of entities through action, the observer is '...able to operate as if external to (distinct from) the circumstances in which he finds himself." (*Op. cit.*, p. 315)

However, the observer is not actually standing apart from those circumstances. This is due to the fact that the entire and the only domain in which he/she operates is that of his/her closed (self-interconnected) nervous system. The nervous system's connectivity and closure permit interactions among its own states at time *t1* to determine its states at time *t2*. This circular interaction allows for '... infinite recursion with continuous behavioural change." (*Op. cit.*, p. 324)

The observer is one of the key concepts in autopoietic theory, because:

"Observing is both the ultimate starting point and the most fundamental question in any attempt to understand reality and reason as phenomena of the human domain. Indeed, everything said is said by an observer to another observer that could be him- or herself."
(Maturana, 1988a, p. 27)

The notion of the observer circumscribes all enquiry and all discussion. This makes autopoietic theory 'relativistic' in the following three ways:

- First, the precise form(s) and function(s) by which systems are distinguished are unavoidably imposed by whatever observer is addressing them. The qualification of any observation with

respect to the vantage point of a given observer makes autopoietic theory inherently relativistic with respect to the person of the observer.

- Second, the resulting qualification of any set of observations over time with respect to the vantage events of a given observer makes autopoietic theory inherently relativistic with respect to the history of the observer.

- Third, since shared or collectively negotiated descriptions of experience (e.g., recollections [past], consensus [present], plans [future]) are qualified with respect to the interactions among given observers, autopoietic theory is inherently relativistic with respect to the persons of interacting observers and their joint history of interactions.

As such, the biology of cognition implies an epistemology (view on knowledge and knowing) analogous to that of *constructivism* -- the view that knowledge of the world is 'constructed' by the knower, and hence must be qualified with respect to the person(s) of the knower(s) being referenced (cf. the work of Heinz von Foerster, Ernst von Glasersfeld, and Jean Piaget).

Explanations and Ontologies: This Theory's Theory on Theory

Explanations

Because the biology of cognition / autopoietic theory is attempting to describe and explain biological and cognitive phenomena with attention to the essential circularities cited earlier, it is necessary to contextualize the theory as a theory. This is necessary because without characterizing the theory in terms consistent with its basic orientations, it will likely be evaluated in the same way as positivistic scientific theories -- i.e., as a set of descriptive / explanatory hypotheses presumed to unambiguously denote objective things within an objectively-manifest world. Such an evaluation will be biased in the sense that it presumes as unquestionable elements which to Maturana and Varela must be qualified with respect to the observer.

Because the biology of cognition / autopoietic theory proceeds with primary regard to the observer, it can only be consistent if its orientation to theory is itself qualified with respect to observers. Although the basic analysis of what 'theory' might mean is implicit in the core literature from the 1970's, Maturana found it necessary to return to this topic and extensively present his positions during the 1980's.

The key concept underlying Maturana's views on theory is that of **explanation**.

"...[A]n explanation is always an intended reproduction or reformulation of a system or phenomenon, addressed by one observer to another, who must accept it or reject it by admitting or denying that it is a model of the system or phenomenon to be explained."

(Maturana, 1978, p. 29)

"An explanation can be characterized as a form of discourse that intends to make intelligible a phenomenal domain that has been recorded. ... [W]hen some domain is deemed explained, and thus rendered intelligible, it is so in reference to a social group of observers."

(Varela, 1979, p. 66)

This non-isomorphism between the explained and the explanation is typically transparent in the course of our everyday praxis of living. Immersed in this praxial flow, we tend to overlook "...that our experience is that we find ourselves observing, talking or acting, and that any explanation or description of what we do is secondary to our experience of finding ourselves in the doing of what we do." (Maturana, 1988a, p. 26) This oversight occurs "...because we normally collapse the experience upon the explanation of the experience in the explanation of the experience." (Maturana, 1988a, p. 27)

An explanation is always a "reformulation" in the sense that its generation by an observer occurs in the domain(s) in which that observer engages the phenomenon being explained, which is not the same as the domain in which the phenomenon is manifested. As a result:

> "...it is the simultaneous logical isomorphism of the new element (relations) [among observer-conjoined domains of interaction] with their source systems through their mode of origin (class intersection) that gives the new domain thus generated (descriptions) its explanatory capacity." (Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 55)

In other words, explanations are categorically distinct from their subject phenomena. This is a key point which is often blurred even among adherents of autopoietic theory, and which is typically ignored in conventional positivistic sciences. If one presumes the world is an objectively-extant thing comprised of objectively-categorized elements, a theory (i.e., an explanation) is assumed to 'mirror reality', and little or no thought is given to how the theory may be qualified with respect to the particular observer(s) generating and/or adopting it.

The most basic explanation of explanatory method given by Maturana necessitates two fundamental operations on the part of the explaining observer:

> "...(a) the specification (and distinction thereof) of the system (composite unity) or phenomenon to be explained; and (b) the identification and distinction of the components and the relations between components that permit the conceptual or concrete reproduction of the system or phenomenon to be explained." (Maturana, 1978)

What, then, is the context within which an observer undertakes explanations? This occurs when the observer formulates or is presented with "...questions that demand an explanation for their answer." (Maturana, 1988a, p. 27) This establishes a situation in which "...we become pacified only when we find an explanatory answer to our question." (*Ibid.*)

A necessary aspect of this situation is that the questioner (original questioner, or another who takes up the question) must have some criteria for acceptance of an answer for it to suffice as such an explanatory (and hence terminal) answer. The questioner (or other awaiting an explanatory answer) "...accepts or rejects a statement as a reformulation of a particular situation of his or her praxis of living, ...[and]...determines whether that statement is or is not an explanation." (Maturana, 1988a, p. 28)

This evaluation is accomplished based on "...whether or not ...[the answer]... satisfies an implicit or explicit criterion of acceptability that he or she applies through his or her manner of listening." (*Ibid.*) Finally, the establishment or adoption of such criteria of acceptability (be they implicit or explicit) entails qualifications with respect to the observer(s) awaiting an answer:

"[E]ach manner of listening of the observer that constitutes a criterion for accepting explanatory reformulations of the praxis of living defines a domain of explanations, and the observers who claim to accept the same explanations for their respective praxes of living."

(Maturana, 1988a, p. 28)

Ontologies

This last quotation implies that different explanations will serve as distinct referential contexts, and that distinct communities of observers accepting those explanations will be oriented to, and proceed with regard to, those explanations. Basically, such an explanation is a theory, and the community of observers incorporating that theory into their praxes of living are its adherents.

Maturana (1988a) uses the label **explanatory path** to denote a composite or encompassing viewpoint or perspective -- the sort of thing we typically take to be a theory or meta-theory. With more specific regard to the fundamental stance adopted in providing an explanation for human cognitive capacities, Maturana identifies two basic explanatory paths. These two paths are distinguished by whether or not they involve *parenthesis* -- a rhetorical / illustrative device employed by Maturana to qualify and clarify his discussion. The point of invoking 'parenthesis' was so Maturana could avoid compromising his non-'objective' orientation in the course of presenting and defending that orientation through the use of admittedly 'objectivity-tainted' language.

The conventional epistemological stance (at least in the West) is one in which discrete referents in the world (i.e, 'objects') in fact *are* 'there' and '*are there just as they seem (to anyone)*'. Within the explanatory framework of autopoietic theory, this position is untenable, because it prioritizes features of the medium *a priori*, without qualification to the process of observation by which those features are educed / apprehended. However, the fact that we are immersed in social, cultural, and disciplinary modes of interactivity predicated on such 'objectivity' makes innovative theorization on cognition (such as autopoietic theory) an exercise in paradox. To overcome this conceptual problem, Maturana introduced 'parenthesis' to surround, and hence qualify, the objective-style language in which he was yet obligated to present his theories.

"The assumption of objectivity is not needed for the generation of a scientific explanation. Therefore, in the process of being a scientist explaining cognition as a biological phenomenon I shall proceed without using the notion of objectivity to validate what I say; that is, I shall put objectivity in parentheses. In other words, I shall go on using an object language because this is the only language that we have (and can have), but although I shall use the experience of being in language as my starting point while I use language to explain cognition and language, I shall not claim that what I say is valid because there is an independent objective reality that validates it."

(Maturana, 1988b, 5.ii.)

This led Maturana to his presentation of the two explanatory paths mentioned above. These are the paths of **objectivity-in-parenthesis** and the path of **objectivity-without-parenthesis**.

The path of objectivity-without-parenthesis is the one best known from Western science. This entails the presumption that statements made about an "objective" world independent of the explaining observer have actual validity -- i.e., such statements are not diluted by qualification of that "objective" status with respect to (a) that observer's biological constitution or (b) whatever apprehensional or

interpretative peculiarities derive from her immersion in her praxis of living (experience).

In this explanatory path:

> "...the observer implicity or explicitly accepts his or her cognitive abilities, as such, as his or constitutive properties, and he or she does so by not accepting, or by rejecting, a complete enquiry into their biological origin."
>
> (Maturana, 1988a, p. 28)

By denying or avoiding this enquiry into the nexus at which the subjects of interest (cognitive capacities) and the instruments by which they are pursued (cognition and language) meet, the observer must look somewhere else for a referential foundation upon which to base analysis. In this path, the observer "...implicitly or explicitly assumes that existence takes place independently of what he or she does, that things exist independently of whether he or she knows them, and that he or she can know them, or can know of them, or can know about them, through perception or reason." (*Ibid.*)

Phrased another way, within the path of objectivity- without-parenthesis the observer prioritizes the extrinsic over the intrinsic, and projects the status of ultimate 'reality' onto that which environs her. Explanations framed within this path therefore point or refer to something "out there": "...some entity such as matter, energy, mind, consciousness, ideas or God..." (*Ibid.*)

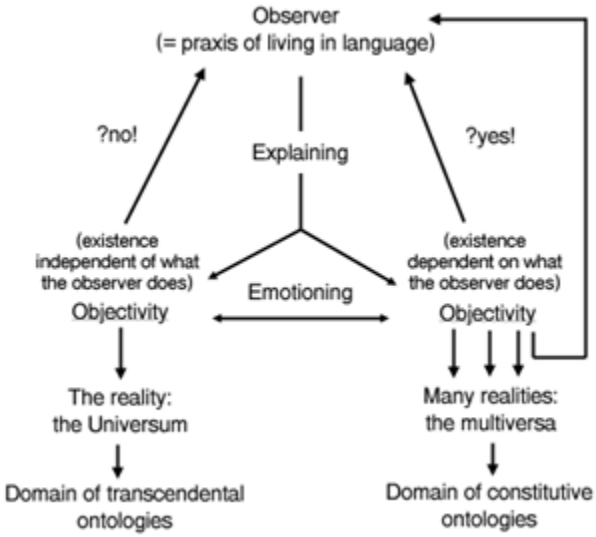
> "[I]t is the listening by the observer with a criterion of acceptability that entails a reference to some entity that exists independently of what he or she does for a reformulation of the praxis of living to be accepted as an explanation of it that constitutes this explanatory path and, in fact, defines it." (Maturana, 1988a, p. 29)

In contrast....

"In the explanatory path of objectivity-in-parenthesis, the observer system explicitly accepts: a) that he or she is, as a human being, a living system; b) that his or her cognitive abilities as an observer are biological phenomena because they are altered when his or her biology is altered; and c) that if he or she wants to explain his or her cognitive abilities as an observer, he or she must do so showing how they arise as biological phenomena in his or her realisation as a living system. Moreover, by adopting this explanatory path, the observer has to accept as his or her constitutive features all constitutive features of living systems, particularly their inability to distinguish in experience what we distinguish in daily life as perception and illusion."

(Maturana, 1988a, p. 29)

The single most detailed discussion of these constructs is to be found in Maturana (1988a), in which he provides (p. 32) one of his rare illustrations (termed the ontological diagram) laying out the relationships between these two modes of explanation. The ontological diagram is illustrated below.



Ontological Diagram (Maturana, 1988a, p. 32)

The path on the left side of the ontological diagram represents objectivity-without-parenthesis. This path acknowledges only a single objective 'universum', and explanations generated within this path are directed toward that single object of reference. Because this path invokes a foundation which transcends the observer's / explainer's own biology and cognition, it generates a domain of 'transcendental ontologies'.

The path on the right side represents objectivity-in-parenthesis. As a secondary or corollary commitment in this path, the observer must accept any and all constitutive features of living systems -- most particularly their imputed inability to distinguish (within the scope of their experience) between perception (i.e., apprehension of something objectively existent) and illusion (a misapprehension of something objectively existent). This has the effect of opening the doors for multiple -- even infinite -- viable or valid explanations, as well as an equivalent diversity of explanatory domains. As such, this explanatory path allows for a multiversum instead of a unary universum.

Explanations generated within this path are qualified with regard to the biology and cognition of the observer(s) involved. Because this path must pay attention to the constitutive features of living systems, it generates a domain of 'constitutive ontologies'.

In Summary:

- The biology of cognition / autopoietic theory is an explanatory framework generated along the explanatory path of objectivity-in-parenthesis.
- In terms of fundamental orientation to 'reality', the biology of cognition / autopoietic theory is presented within the domain of constitutive ontologies.

Part II - Concepts and Constructs

Mechanicism: The Explanatory Approach

Here in Tutorial 2, we shall explore the concepts and constructs by which Maturana and Varela explain living systems and their phenomenology. Before we begin this exploration, we should acknowledge the particular 'stance' or 'approach' Maturana and Varela employed in undertaking their explanations. Recall (cf. Tutorial 1) that autopoietic theory is characterized as following the explanatory path of **objectivity-in-parenthesis**. This path acknowledges the biological basis of the observer as the starting point for explaining cognition. The other path (objectivity-without-parenthesis) is characterized by a negligence to or rejection of the biological basis for the observer. The path of objectivity-without-parenthesis subsumes those explanations whose starting point is an 'objective reality' external to the observer (e.g., the physicists' basis of atoms and molecules). This does not , however, mean the path of objectivity-in-parenthesis denies or rejects the relevance of what lies outside the observer-unity's boundary. It only means the path of objectivity-in-parenthesis rejects the *objectivity* of an observer's knowledge of such extrinsic elements (i.e., their being knowable without qualification vis a vis the observer's biological nature and circumstances of observation).

This point is crucial to prevent astonishment upon learning that Maturana's and Varela's theoretical efforts were undertaken with strict regard to the physical universe within which living systems are embedded. In their early joint papers their approach was characterized as **mechanicism**. The admitted connotations of this mechanicism included ".. a biological outlook which asserts that the only factors operating in the organization of living systems are physical factors, and that no non-material vital organizing force is necessary." (Maturana & Varela,1980, p. 137) Phrased another way, this is an explanatory stance from which "...[n]o forces or principles will be adduced which are not found in the physical universe." (Varela, 1979, p. 6)

At this point you may be wondering if this mechanicism somehow contradicts the claim that the biology of cognition is itself an exercise in the explanatory path of objectivity-in-parenthesis. The answer to that question is, "No, there is no contradiction." The basis for that answer is that Maturana and Varela's mechanicism, though framed with regard to the tangible, is not dependent upon tangibility. Phrased another way, the fact that living systems were to be addressed solely in terms of 'physical factors' does not mean they were to be explained in terms of their 'physicality' -- i.e., the properties of the physical components constituting the living system.

> "...[O]ur problem is the living organization, and therefore our interest will not be in properties of components, but in processes and relations between processes realized through components." (Varela, 1979, p. 6)

Maturana and Varela's mechanistic allusions extended to addressing living systems as 'machines'. Indeed, the seminal definitions for the concept of autopoiesis were presented as descriptions of an 'autopoietic machine'. The invocation of the term 'machine' stripped away fuzzy vitalistic attributions and afforded a clear focus on the living system in terms of what it essentially is and how it most essentially operates.

"In saying that living systems are "machines", we are pointing to several notions that should be made explicit.

- **First, we imply a nonanimistic view, which it should be unnecessary to discuss any further.**
- **Second, we are emphasizing that a living system is defined by its organization, and hence**

that it can be explained as any organization is explained, that is, in terms of relations, not of component properties.

- **Finally, we are pointing out from the start the dynamism apparent in living systems and which the word "machine" or "system" connotes."**

(Varela, 1979, p. 7, vertical spacing added for readability)

Because autopoietic theory was undertaken from the starting point of the observer's biological nature, it is consistent with the explanatory path of objectivity-in-parenthesis. In addition, the explanatory stance emphasizing relations is an instance of what Maturana would later call a **mechanistic explanation**:

"In a mechanistic explanation, the observer explicitly or implicitly accepts that the properties of the system to be explained are generated by relations of the components of the system and are not to be found among the properties of those components. The same applies to the mechanistic explanation of a phenomenon, in which case the observer explicitly or implicitly accepts that the characteristics of the phenomenon to be explained result from the relations of its constitutive processes, and are not to be found among the characteristics of these processes. ... In a mechanistic explanation the relations between components are necessary ..."

(Maturana, 1978, p. 30)

Now that the explanatory path and the explanatory approach have been presented, we are now ready to look into the theory's best-known concept -- autopoeisis.

Autopoiesis and Autonomy

To many people, Maturana and Varela's work boils down to one thing -- the concpet of autopoiesis. This is why the body of Maturana and Varela's work is commonly labeled "autopoiesis", "theory of autopoiesis", and "autopoietic theory."

Maturana (cf. Maturana and Varela, 1980, p. xvii) coined the term around 1972 by combining the Greek **auto** (self-) and **poiesis** (creation; production). This combination of connotations was required to label the type of phenomenon which Maturana and Varela had identified as the definitive characteristic of living systems.

It is important to bear in mind that the construct of 'autopoiesis' was developed to characterize living systems (as opposed to any other systems). Maturana's original goal was to develop a novel perspective on perception and cognition. His starting point was the claim that "cognition is a biological phenomenon." In the course of his pursuit he found it understandably necessary to specify what 'biological phenomenon' means. This in turn meant he had to devise a definition of living systems before he and Varela could explain cognition as a biological phenomenon. 'Autopoiesis' became the core of the required definition, and as such it served as the explanatory context for subsequent constructs and concepts addressing the phenomenology of living systems.

Now let's move on to see what 'autopoiesis' is...

Living systems are composite unities (cf. Tutorial 1) -- i.e., they are comprised of components which cooperatively participate in realizing the system as a unary whole. However, there are composite unities which we do not consider to be living (e.g., bicycles or computers). To define living systems requires explaining what it is about them that distinguishes them from other composite unities.

As Maturana (1980a, p. 45) puts it, the concept of autopoiesis:

> "...resulted from the direct attempt ... to provide a complete characterization of the

organization that makes living systems self-contained autonomous unities, and that makes explicit the relations among their components which must remain invariant under a continuous structural transformation and material turnover."

Living systems (like all composite unities) exhibit both organization and structure (cf. the preceding section). The mere presence of organization and structure cannot therefore distinguish living systems from other systems. Maturana and Varela's insight was that living systems are peculiar in the sense that their organization is such as to facilitate their structure being continuously maintained. This structure is constantly being 'regenerated' through the production of new components.

In other words the living system is a living system because it produces itself via production of its own components. More specifically, the living system is a composite unity whose components constitute it via interwoven processes which generate the components themselves.

This was this perspective of intra-system component production within which Maturana and Varela framed the canonical definition for 'autopoiesis':

Autopoiesis

"An autopoietic system is organized (defined as a unity) as a network of processes of production (transformation and destruction) of components that produces the components that:

1. **through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and**
2. **constitute it (the machine) as a concrete unity in the space in which they [the components] exist by specifying the topological domain of its realization as such a network."**

(Varela, 1979, p. 13)

Any unity meeting these specifications is an autopoietic system, and any such autopoietic system realized in physical space is a **living system**.

What makes 'autopoiesis' distinctive as a definition for living systems?

If you go back and check most definitions (e.g., in a biology textbook), you are likely to find nothing more coherent than a list of features and functional attributes (e.g., 'reproduction', 'metabolism') which describe what living systems do, but not what they are. Because it is framed with respect to the constitution of a living system (as a specific class of systems), autopoiesis is a unique means for defining living systems in terms of their essential character (as opposed to their subsidiary features).

Autopoietic theory provides the primary (perhaps the only...) definition for life which is framed purely with respect to a candidate system in and of itself.

A deeper discussion of this theory's ramifications for biology is beyond the scope of this tutorial. If you want to explore this issue more deeply, you can begin with the following article:

Margaret A. Boden, Autopoiesis and life, *Cognitive Science Quarterly*, (2000), no. 1, pp. 117-145.

Available in PDF (Adobe Acrobat Reader) format at:

http://www.iig.uni-freiburg.de/cognition/csq/pdf-files/boden.pdf

How does one determine if an entity is autopoietic?

Varela, Maturana and Uribe (1974) laid out a six-step procedure for judging whether a composite unity is autopoietic. I have adapted that procedure to produce the *Autopoiesis Checklist* as a quick guide to evaluating whether or not an entity is autopoietic.

Two key points to bear in mind:

(1) *Autopoiesis is not the entirety of autopoietic theory.*

The fact that cognition was analyzed and explained in the context of autopoietic living systems does not mean that all constructs and concepts of autopoietic theory necessarily entail 'autopoiesis'. Neither does it mean that any application of Maturana and/or Varela's ideas must proceed from the basis of first evaluating an object of interest (e.g., a social network, a business process) as autopoietic.

(2) *'Self-(re-)production' is not the entirety of 'autopoiesis'.*

The term 'autopoiesis' is commonly cited only in terms of meaning 'self-production'. The component-production perspective in which the canonical definition was framed reinforces this apparent priority on production. However, this is not the entirety of the concept. If you leap to the conclusion that autopoiesis is primarily a matter of (re-)producing one's own structure, you will miss the truly central theme of the concept.

The particular manifestation of a given unity -- its **structure** -- is not sufficient to define it as a unity. The key feature of a living system is maintenance of its **organization**, i.e, preservation of the relational network which defines it as a systemic unity. This organizational invariance or persistence is the critical outcome of 'autopoiesis', whereas componential (re-)production is the means by which it is accomplished.

The centrality of organizational preservation is illustrated by the fact that it is this (and not componential (re-)production) which Maturana cites in offering the single most concise definition of 'autopoiesis' to be found in the literature:

"...[A]utopoietic systems operate as homeostatic systems that have their own organization as the critical fundamental variable that they actively maintain constant."

(Maturana, 1975, p. 318)

We therefore see the concept of 'autopoiesis' involves both organizational preservation and componential (re-)production, with the former being the central theme and the latter being the specific means characteristic of the class of autopoietic systems.

This way of looking at the concept raises the issue of whether or not autopoietic systems are a subclass of a more general class delineated in terms of organizational preservation. Phrased another way, the distinctions drawn above leave room to wonder if autopoietic systems are distinguished by their componential self (re-)production from a broader family of system types delineated within a broader context.

This was one of the themes Varela pursued in his work during the mid- to late 1970's. Varela expanded on autopoietic theory's original formalizations to delineate the systemic attribute of **autonomy**, of which autopoiesis is a subset.

The formal specification of autonomy is given in the following quote:

Autonomy

[Autonomous systems are] "...defined as a composite unity by a network of interactions of components that

(i) through their interactions recursively regenerate the network of interactions that produced them, and

(ii) realize the network as a unity in the space in which the components exist by constituting and specifying the unity's boundaries as a cleavage from the background..."

(Varela, 1981, p. 15)

The difference between autonomy and autopoiesis is that autopoietic systems must produce their own components in addition to conserving their organization. Beyond this one distinction, autonomous systems exhibit the same defining characteristics originally specified for autopoietic systems.

Varela (1979) does not simply define autonomous systems as autopoietic systems minus the self-production of components. He emphasizes that the more general class of autonomous systems is defined by the attribute of **organizational closure**. The formal specification for this concept is given in the following quote:

Organizational Closure

[Systems exhibit organizational closure if...] "...their organization is characterized by processes such that

1. **the processes are related as a network, so that they recursively depend on each other in the generation and realization of the processes themselves, and**
2. **they constitute the system as a unity recognizable in the space (domain) in which the processes exist."**

(Varela, 1979, p. 55)

It is important to note that this property of 'closure' does not make autonomous systems 'closed' in the classic cybernetic sense of 'isolated from the environment; impervious to environmental influence'.

'Closure' doesn't mean autonomous systems are unresponsive; it only means that their changes of state in response to changes in their medium are realized and propagated solely within the network of processes constituting them (as they are defined).

Phrased another way, the difference has more to do with the way a system is defined than how that system (once defined) operates. A fuller explanation of this point can be obtained in Varela (1979).

The utility of autonomy versus autopoiesis

The organizational closure that defines autonomous systems is the characteristic most closely linked to the behavior of those systems being guided by their constitutions (as opposed to being determined by external causative events). Invoking autonomy, rather than autopoiesis, allows you to address and analyze a system's operations without the necessity of either demonstrating or reducing your explanations to the process of componential self (re-)production.

Some of the fields in which Maturana and Varela's work has been applied attempt to address as 'systems' entities which are difficult to describe (much less explain) in terms of their components and the self (re-)production of those components. The classic example is the 'social system' -- a composite entity clearly comprised of its participating (biological) social actors, but difficult to treat as the

necessary producer of these human components. Much of the work dedicated to analysis of social systems as autopoietic has bogged down on demonstration of autopoiesis in the 'social space'. Indeed, no such analysis has yet succeeded in demonstrating social autopoiesis in terms of the clear-cut criteria found in the core literature (cf. the *Autopoiesis Checklist*).

Such impasses might well be avoided if analysts were to approach their subject matter in terms of autonomy rather than autopoiesis. Unfortunately, it would appear few if any researchers in these other fields are cognizant of the autonomy / autopoiesis distinction.

Structural Determination

The organization and structure of a structure-determined system ... continuously determine:

(a) the domain of states of the system, by specifying the states that it may adopt in the course of its internal dynamics or as a result of its interactions;

(b) its domain of perturbations, by specifying the matching configurations of properties of the medium that may perturb it; and

(c) its domain of disintegration, by specifying all the configurations of properties of the medium that may trigger its disintegration.

(Maturana, 1978a, p. 34, vertical spacing added for readability)

Structural determination is the principle that the actual course of change in a systemic entity is controlled by its structure (the totality of specific components' individual and synergistic properties within the arrangement by which they constitute the system) rather than direct influence of its environment.

The basic thrust of this principle is that the behavior of a system is constrained by its constitution, and potential system changes are circumscribed by:

- the system's range of potential structural transformations
- the set of potential perturbations impinging upon the system

Actual change is compensable behavior by the system's structure under perturbation by the environment and / or other systems in the course of its operation (cf. 'structural coupling', defined below). While a given perturbation may 'trigger' a change of system state, the particular change triggered is a function of the system's own organization and structure.

Since 'structure' refers to any constitutive element of a discerned unity, structural determination concerns the manner in which observed (-able) phenomena are explained, not some formalized manner in which those phenomena objectively occur. As such, structural determination is not simply a variation on materialistic reductionism, but an epistemological qualification.

Structural determination should not be equated with strict causal determinism, in which all specific interactions are predetermined. It only means the space of all possible classes of interactions is determined.

For example, in re-engineering an enterprise, the subject's structure does not uniquely predict its best new form. However, its structure circumscribes the range of new forms into which it can evolve without violating its organization (i.e., ceasing to exist as its current identity).

Structural determination does not constrain the set of interactions in which a system can be observed to engage -- only the set in which that system can observe itself to be engaged:

> "If the living system enters into an interaction not prescribed by its organization, it enters it not as the unit of interactions defined by this organization ... and this interaction remains outside its cognitive domain."
>
> (Maturana, 1970, p. 6)

This point is important to enterprise analysts and (re-)engineers. To the extent they proceed as observers 'external' to everyday operations, they engage enterprises at the intersection of the enterprise's domain of operations and their own domain of analytical activity. The behavior analysts observe in this 'intersection zone' may not be either representative of, or defined in accordance with, the domain of enterprise operations in which it is ordinarily realized.

Structural Coupling

"In general, when two or more plastic dynamic systems interact recursively under conditions in which their identities are maintained, the process of structural coupling takes place as a process of reciprocal selection of congruent paths of structural changes in the interacting systems which result in the continuous selection in them of congruent dynamics of state."

(Maturana & Guiloff, 1980, p. 139)

Structural coupling is the central explanatory construct provided by autopoietic theory in addressing interaction / interactivity among systems or unities.

Given the principle of structural determination, interaction among systems is explained as "...a history of recurrent interactions leading to the structural congruence between two (or more) systems." (Maturana & Varela, 1987, p. 75).

Structural coupling, then, is the term for structure-determined (and structure-determining) engagement of a given unity with either its environment or another unity. *Ontogeny* -- "the history of the structural transformations of a unity" (Maturana & Varela, 1980, p. 137) -- is the course of an organism's structural coupling. Put another way, ontogeny is "...the history of maintenance of [the system's] identity through continuous autopoiesis in the physical space." (Varela, 1979, p. 32) The reason Varela qualifies ontogenic coupling with respect to the physical space is that he was addressing living systems realized in that space (cf. earlier definition of living systems).

[Structural coupling is] "...a historical process leading to the spatio-temporal coincidence between the changes of state.." [in the participants.]

(Maturana,1975, p. 321)

[Structurally-coupled systems] "... will have an interlocked history of structural transformations, selecting each other's trajectories."

(Varela, 1979, pp. 48-49)

As such, structural coupling has connotations of both coordination and co-evolution.

It connotes 'coordination' in the sense that the coupled systems will (to an observer) exhibit some measure of correspondence or correlation in the manner and the course of their behaviors during coupling.

It connotes 'co-evolution' in the sense that the behaviors of the coupled systems may (to an observer) exhibit some measure of progressive individual 'attunement' during coupling and/or as a persistent (apparent) result of coupling.

In conjunction with the principle of **structural determination**, this provides a novel perspective on the interplay among systemic unities. The effect of the coupled behavior (e.g., 'coordination' / 'co-evolution') is thereby qualified with respect to the structures of the interacting systems, and not to some additional explanatory referent 'projected' onto the situation.

Case 1: A System Coupling with its Environment

"If one of the plastic systems is an organism and the other its medium, the result is ontogenic adaptation of the organism to its medium: the changes of state of the organism correspond to the change of state of the medium."

(Maturana, 1975, p. 326)

This is the case addressing the ongoing interaction(s) between (e.g.) a living system and its environs.

The reciprocal effect of organism and environment on each other provides an explanatory basis for addressing:

- The particular state(s) in which these coupled unities / systems are observed
- The course or trajectory of states observed over time
- The ultimate viability of the organism to continue operation in the given environment

...as illustrated by the following passage:

"(T)he continued interactions of a structurally plastic system in an environment with recurrent perturbations will produce a continual selection of the system's structure. This structure will determine, on the one hand, the state of the system and its domain of allowable perturbations, and on the other hand will allow the system to operate in an environment without disintegration."

(Varela, 1979, p. 33)

Case 2: A System Coupling with Another System

"If the two plastic systems are organisms, the result of the ontogenic structural coupling is a *consensual domain*."

(Maturana, 1975, p. 326)

This case is the one most commonly invoked, because it sets the stage for addressing linguistic interactivity in mechanicistic terms.

In this case, however, the juncture between two observers in coupling is itself a higher-order domain of description, for which a specific label ("consensual domain") is provided.

A consensual domain is therefore defined as ".. a domain of interlocked (intercalated and mutually triggering) sequences of states, established and determined through ontogenic interactions between structurally plastic state-determined systems." (Maturana, 1975, p. 316).

"In each interaction the conduct of each organism is constitutively independent in its generation of the conduct of the other, because it is internally determined by the structure of the behaving organism only; but it is for the other organism, while the chain [of interactions] lasts, a source of compensable deformations that can be described as meaningful in the context of the coupled behavior."

(Varela, 1979, pp. 48 - 49)

Because consensual domains are defined both by the structures of their participants and the history by which they came to exist, they are not reducible to descriptions framed only in terms of either:

Phrased in a slightly different way, the participating systems reciprocally serve as sources of **compensable perturbations** for each other.

The effects of interaction on each participating system are 'perturbations' in the sense of indirect effect or effectuation of change without having penetrated the boundary of the affected system.

These effects are 'compensable' in both the senses that:

1. there is a range of 'compensation' bounded by the limit beyond which each system ceases to be a functional whole, and
2. each iteration of the reciprocal interaction is affected by the one(s) before.

This is why the structurally-coupled systems "... will have an interlocked history of structural transformations, selecting each other's trajectories." (Varela, 1979, pp. 48 - 49)

The notions of 'structural determination' and 'structural coupling' provide a basis for addressing human (inter-)activity in new and constructive ways.

To give a specific example, structural coupling describes inter-human communicative activity without being based upon allusion to a transfer of some ephemeral force or information across the boundaries of the interactors.

To give another example, this permits analysis of enterprises and their operations in terms of their general and actual form (i.e., their organization and structure). This approach maintains a focus on the subject enterprise and minimizes counterproductive bias toward *a priori* allusions to abstractions such as 'information flows', 'market forces', and the like.

Cognition as (Inter-) Activity

"Living systems are cognitive systems, and living as a process is a process of cognition."

(Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 13)

We attribute **'cognition'** to a system when it is able to discriminate (in terms of response) among unit phenomena in its medium, synchronically (at a given moment) and diachronically (over time).

The evidence for this 'cognition' is effectiveness of system behavior in response to the dynamics of its milieu.

Today's dominant perspective on cognition is 'cognitivism' -- the idea that effective action is explainable in terms of algorithmic procedures for manipulating abstracted 'data' with respect to 'knowledge structures'. This approach is best known from the 'Human Information Processing' (HIP) school of psychology, artificial intelligence (AI), and the 'cognitive sciences' lying at their intersection. During the last decade, there has been a growing realization that cognitivism is at best a limited way of analyzing humans and their interactivity (cf. Winograd & Flores, 1986).

"A cognitive system is a system whose organization defines a domain of interactions in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaving in this domain."

(Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 13)

Cognition is contingent on embodiment, because this ability to discriminate is a consequence of the organism's specific structure. From this perspective, cognition is what we attribute to systems

exhibiting flexible and effective changes during **structural coupling**. A living system's organization circumscribes a domain of interactions within which activity relevant (and appropriate) to maintaining its autopoiesis is manifested.

Owing to this perspective, the object of cognition (e.g., the 'real world' or 'the environment') is necessarily qualified with respect to the observing organism. '[F]or every living system, its organization implies a prediction of a niche, and the niche thus predicted as a domain of classes of interaction constitutes its entire cognitive reality." (Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 11)

In later writings, this circumscribed 'cognitive reality' is usually termed a **cognitive domain** -- "... all the interactions in which an autopoietic system can enter without loss of identity..." or, with regard to the system as an observer, "...the domain of all the descriptions which it can possibly make." (Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 136)

Cognition in the autopoietic view is no more and no less than a living system's effective behavior within its domain of interactions. In other words, cognition is a matter of interacting in the manner(s) in which one is capable of interacting, not processing what is objectively there to be seen. As such, Maturana and Varela do not address cognition in the currently conventional sense as an internal manipulation of extrinsic 'information' or 'signals', as the cognitivist viewpoint would have us believe:

> "This would mean that such inputs or outputs are part of the definition of the system, as in the case of a computer or other machines that have been engineered. To do this is entirely reasonable when one has designed a machine whose central feature is the manner in which we interact with it. The nervous system (or the organism), however, has not been designed by anyone... (T)he nervous system does not 'pick up information' from the environment, as we often hear... The popular metaphor of calling the brain an 'information-processing device' is not only ambiguous but patently wrong."
> (Maturana & Varela, 1987, p. 169)

A full exploration and analysis of Maturana and Varela's views on cognition lies well outside the scope of this brief Tutorial.

For now, it must suffice to say that their reinterpretation of cognition grounds cognitive activity in the embodiment of the actor and the specific context of activity. As such, autopoietic theory fits very well with current trends toward emphasizing 'contextualization' and 'auto-determination' studies of humans, their interactions, and their social systems.

Varela *et al.* (1991) provide a recent extension of these principles into an **enactive cognitive science**, which will be introduced and discussed later in this Tutorial.

Languaging

Building from the tenets of structural determinism and structural coupling, Maturana constructs a model of languaging -- activity in which interactors mutually orient themselves to each other and to a subject.

"Linguistic behavior is orienting behavior; it orients the orientee within his cognitive domain to interactions that are independent of the nature of the orienting interactions themselves.

To the extent that the part of its cognitive domain toward which the orientee is thus oriented is not genetically determined and becomes specified through interactions, one organism can in principle orient another to any part of its cognitive domain by means of arbitrary modes of conduct also specified through interactions. However, only if the domains of interactions of the two organisms are to some extent comparable, are such consensual orienting interactions possible

and are the two organisms able to develop some conventional, but specific, system of communicative *descriptions* to orient each other to cooperative classes of interactions that are relevant for both."

(Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 30)

Mutual Orientation in Conversation

'Orientation', as used here, does not mean directed acknowledgement or knowledge of some objective entity (cf. colloquial use of 'orientation' to mean 'instruction'). Instead, it refers to three types of co-orientations (coordinations) enacted within conversations among the interactors:

Coordination of embodiment

> Coordination of embodiment refers to structural changes in the bodyhoods of the interactors. Co-orientation in terms of bodyhood (as contrasted with descriptions / explanations) is primarily a matter of facilitating the "mechanics" of interaction (e.g., addressing each other via posture, voice, etc.). This form of orientation is generally not available to an (external) observer.

Coordination of emotions

> The second type of coordination is coordination of emotions. Maturana (1988a, p. 49) defines **emotions** in terms of "...dynamic body dispositions for actions ... that specify at any moment the domains of action in which the organisms move." As organisms, we are subject to emotioning -- "...a continuous flow of emotions and moods ... that changes the domain of actions in which the organisms move and operate, ... in a manner contingent on the course of their interactions." (Ibid.) The relevance to interaction is that "...languaging flows in the co-ordination of actions of human beings in a background of emotioning that constitutes the operational possibility of its occurrence, and specifies at any instant the consensual domains in which it takes place." (Ibid.) Coordinations of emotions are observable as coordinations of domains of action.

Coordination of actions

> This third type of coordination does not refer to "coordination" in the sense of planning future activity. Instead, it connotes progressive harmonization in the behavior(s) of interacting unities. These are the primary orientational foci which will be explored further -- the progressive co-orientation of actions which an observer educes as common or similar behaviors indicative of (e.g.) protocol or consensus. Here lies the intersection with conventional accounts of discourse as a 'rational' activity, for Maturana defines rationality as "...the operation of the observer according to the operational coherences of languaging in a particular domain..." (Maturana, 1988a, p. 42).

Maturana's view of conversations as orientational dance is quite distinct from conventional perspectives on interactions in language. In colloquial discussions generally (and cognitivism specifically), interpersonal communication is typically treated as a 'piping' of 'information' among conversants. This view presumes 'information' is a quantum commodity, and it shifts the focus of observation from interactors to a presumed commerce in this commodity.
In their book *Metaphors We Live By*, Lakoff and Johnson describe this view as a 'conduit metaphor' for communication, as illustrated below.

The Conduit Metaphor for Communication
(from Whitaker, 1992)

The notion of the conduit metaphor originated with Reddy (1979). The purported viability of this metaphor is based on the following assumptions:

1. "language functions like a conduit, transferring thoughts bodily from one person to another;
2. in writing and speaking, people insert their thoughts or feelings in the words;
3. words accomplish the transfer by containing the thoughts or feelings and conveying them to others; and
4. in listening or reading, people extract the thoughts and feelings once again from the words." (Reddy, 1979, p. 290)

Maturana and Varela (1987, p. 196) directly address the conduit metaphor (using the label "metaphor of the tube"). Their rebuttal of this viewpoint is based on their own principle of structural determination. They note that cognitivistic approaches conventionally treat this commerce in 'information' as a process through which the 'receiver' adopts a state determined by the state of the 'sender' as projected via the 'message', "...as though what happens to a system in an interaction is determined by the perturbing agent and not by its structural dynamics..." (Maturana & Varela, 1987, p. 196). Maturana (1978a) labels such events **instructive interactions**.

To say that the perturbations determine the state of the receiver is to put explanatory emphasis on the perturbations themselves, and this is why cognitivists prioritize the symbols and the signals over the interactors. In other words, for a sender to project 'meaning' in her symbolic utterances there must be 'meaningfulness' attributable to the symbols themselves. This is why the cognitivistic view of language concentrates on "...a denotative system of symbolic communication, consisting of words that denote entities regardless of the domain in which these entities may exist." (Maturana & Varela, 1980, p.50) The problem is that such an approach fails to explain how denotation can become conventionalized among interactors. It overlooks the fact that "Denotation ... requires agreement -- consensus for the specification of the denotant and the denoted." (*Ibid.*)

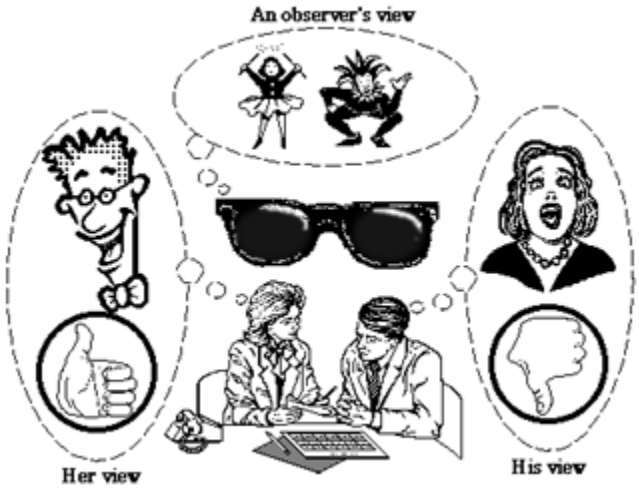
"So long as language is considered to be denotative it will be necessary to look at it as a means for the transmission of information, as if something were transmitted from organism to organism, in a manner such that the domain of uncertainties of the 'receiver' should be reduced according to the specifications of the 'sender'. However, when it is recognized that language is connotative and not denotative, and that its function is to orient the orientee within his cognitive domain without regard for the cognitive domain of the orienter, it becomes apparent that there is no transmission of information through language. It behooves the orientee, as a result of an independent internal operation upon his own state, to choose where to orient his cognitive domain; the choice is caused by the 'message', but the orientation thus produced is independent of what the 'message' represents for the orienter. In a strict sense then, there is no transfer of thought from the speaker to his interlocutor; the listener creates information by reducing his uncertainty through his

interactions in his cognitive domain."

(Maturana, 1970: reprinted in Maturana & Varela, 1980, p. 32)

In analyzing actual communication, the prevailing approach (presuming both denotation and the conduit metaphor) is very problematical. For most analytical purposes, communication is of interest with regard to what happens with or to the person 'receiving' it ('persons' in the case of reciprocal dialogue or one-to-many broadcasting). Because a quantum 'information' commodity is not defined with regard to the structure of the interactor(s), focusing on the 'message' blinds an observer (e.g., an enterprise analyst) to the actor and her activity during conversation. This leaves the analyst to wonder about cases in which apparently clear-cut 'messages' were not 'instructive' -- i.e., didn't induce the effect of their content.

In my long experience with team decision processes and other collaborative activities, I've found that such cases tend to be the rule and not the exception. For example, meeting participants are often operating with very different views of topics, intentions, and outcomes. Meeting participants may These in turn may be quite different from the views or orientations of an observer watching the interaction. This lack of consensual orientation is illustrated below.



Ambiguity in Communication
(from Whitaker, 1992)

If one presumes instructive interactions, this sort of divergent orientation among interactors must be taken as evidence that either (a) the interactors are impeded in 'being instructed' (in the sense described above) or (b) the fault lies within the denotative system itself (i.e., suboptimal symbolizations). The most straightforward explanation is that of Maturana and Varela -- i.e., that language is connotative, and meaning is constructed rather than absorbed by the listener.

Now let's make another, deeper, pass through this theory's interpretation of linguistic behaviors...

"If recursion is possible in a particular kind of behavior ... a closed generative domain of behavior is produced. ... What is peculiar about a language, however, is that this recursion takes place through the behavior of organisms in a consensual domain."

(Maturana, 1978a, p. 52)

Maturana views language as the archetypal illustration of a human consensual domain.

Linguistic interaction is a venue for action, coupling the cognitive domains of two or more actors. This is reflected in Maturana's preference for discussing **languaging** (the act) as opposed to 'language' (a symbolic schema).

The primary function of linguistic interaction is therefore not conveyance of 'information quanta', but the mutual orientation of the conversants within the consensual domain realized by their interactivity. 'Communication' becomes a matter of mutual orientation -- primarily with respect to each other's behavior, and secondarily (only via the primary orientation) with respect to some subject. This is extremely important for delimiting the constraints on an observer's (e.g., an enterprise analysts') analysis of communicative interactions. In today's conventional (e.g., cognitivistic) approaches, such interaction is described as a semantic coupling -- a process by which each of the observed interactors computes the appropriate response state from some informative input from the other. Maturana warns that this is not warranted ...

Maturana argues against this notion of semantic coupling...

"(a) because the notion of information is valid only in the descriptive domain as an expression of the cognitive uncertainty of the observer, and does not represent any component actually operant ... and (b) because the changes of state of a [structurally] determined system, be it autopoietic or not, are determined by its structure, regardless of whether these changes of state are adequate or not for some purpose that the observer may consider applicable."

(Maturana, 1975, p. 322)

This moves linguistic interaction to a conceptual base whose elements apply to a much broader range of actors and interactions than symbolic data. The structural coupling of the participating organisms is the only operative element -- all other items treated in descriptions of linguistic behavior are secondary.

How, then, can one account for the seemingly secure framework within which we ordinarily consider conversation to occur -- shared lexicons, objective meanings, and syntactic conventions?

Maturana's writings evidence the following rebuttals:

1. such a question is biased in its presumption that such a framework objectively exists, and
2. such regularities are imposed by an observer.

"[T]he superficial syntactic structure or grammar of a given natural language can only be a description of the regularities in the concatenation of the elements of the consensual behavior. ...This superficial syntax can be any, because its determination is contingent on the history of consensual coupling ... (T)he 'universal grammar' of which linguists speak as the necessary set of underlying rules common to all human natural languages can refer only to the universality of the process of recursive structural coupling."

(Maturana, 1978a, p. 52)

The reclassification of communicational behavior from conceptual commerce to mutual orientation expands the range of behaviors we may consider as 'communicative'.

The autopoietic view of language is not constrained to coded symbols for the manner in which interactors couple. "The richness attained by a language ... depends necessarily both on the diversity of behaviors that can be generated and distinguished by the organisms that participate in the consensual domain, and on the actual historical realization of such behaviors and distinctions." (*Op. cit.*, p. 51)

By disengaging interaction from lexical reference and grammatical performance, the autopoietic model implicitly allows for all manner of non-verbal or extra-verbal signalling -- a scope more akin to semiotics than mainstream linguistics.

By linking linguistic interaction with structural coupling, the context for signification (determination of meaning) is unified with the context of the interaction. This unification 'grounds' context in the individual's experience, rather than leaving it as a receding horizon of meta-symbolic determinants.

This in turn unifies the two senses of 'context'-- determinant of linguistic 'meaning' and relevant situational background. This affords autopoietic theory a sound basis for addressing the context-dependent aspects of actual interactions.

NOTE:

Maturana (1978a) is the key source for autopoietic theory's account of linguistic interaction. If you'd like to read it in its entirety (and its original published form), you can jump to the *Observer Web Archive Edition* of this article (recommended only after you finish the Tutorial). The full URL for this resource is:

http://www.enolagaia.com/M78BoL.html

Enaction

"...[T]he mind-body question need not be, What is the ontological relation between body and mind, regardless of anyone's experience? -- but rather, What are the relations of body and mind in actual experience ... how do these relations develop, [and] what forms can they take?'

(Varela, Thompson & Rosch, 1991, p. 30)

Autopoietic theory's formal tenets provide us with novel means for explaining how biology underlies cognition. However, the ongoing processual flow of cognition is not so clearly explained, even though (as a process) its basic mechanisms have been described. The next step is to delve into the observing system's phenomenology -- 'the domain of all the phenomena defined in the interactions of a class of unities' (Maturana & Varela, 1987, p. 253). To address the phenomenology of everyday life one must shift the focus to those interactions through which lived experience is realized.

In their 1991 book *The Embodied Mind*, Varela, Evan Thompson and Eleanor Rosch bring phenomenological concerns into the world of cognitive science. Their goal is to incorporate everyday experience into the scope of studies which have heretofore addressed cognition in terms of disembodied rational processes, circumscribed by abstract concept units purported to mirror an objective milieu. This situation derives from the Western segregation of mind and body, a perspective commonly attributed to Rene Descartes.

"Our science has been founded on simple location and misplaced concreteness' [and it] 'divides the seamless coat - or to change the metaphor into a happier form, it examines the coat, which is superficial, and neglects the body, which is fundamental. The disastrous separation of body and mind which has been fixed on European thought by Descartes is responsible for this blindness of science." -- Alfred North Whitehead

Varela *et al.* reject Cartesian dualism because it has forced Western philosophers to postpone addressing experience until both the mind and body involved in experiencing have themselves been analyzed. Such analysis is necessarily hampered (if not prevented) by the fact that the segregation of mind from body leaves two competing starting points from which to proceed. Varela and his co-authors term the resulting malaise *Cartesian anxiety* -- an overwhelming desire for some fixed ontological reference point, and a corresponding dread of the chaos presumed to be the only alternative.

In Western philosophy, this fetish for fixity has historically led to prioritizing one of two foundations. Choosing the body (the material, the objective) leads in the extreme to a position of philosophical realism. Choosing the mind (the abstract, the subjective) leads in the extreme to the opposite position of philosophical idealism. These polar positions are twin horns of the dilemma for cognitive science -- these extremes "...both take representation as their central notion: in the [realist] case representation is used to recover what is outer; in the [idealist] case it is used to project what is inner." (Ibid., p. 172)

In *The Tree of Knowledge* Maturana and Varela (1987) characterized this dilemma as "(t)he epistemologic Odyssey: sailing between the Scylla monster of representationism and the Charybdis whirlpool of solipsism" (p. 134, Figure 35) "On one side there is a trap: the impossibility of understanding cognitive phenomena if we assume a world of objects that informs us because there is no mechanism that makes that "information" possible. ...On the other side, there is another trap: the chaos and arbitrariness of nonobjectivity... " (Maturana & Varela, 1987, p. 133)

In *The Embodied Mind*, Varela *et al.* restate this more precisely as "...the Scylla of cognition as the recovery of a pregiven outer world (realism) and the Charybdis of cognition as the projection of a pregiven inner world (idealism)." (p. 172) This later version clearly centers on representation as the crux of the matter -- objectivism mandating projection of its intrinsic features onto a passively reflective nervous system (mind as speculum mundi), and subjectivism mandating actively projection of the observer's intrinsic ideal(s) onto a reflective medium (world as mirror of the mind).

One of the dangers in this dilemma is the confusion caused by using 'mind' to understand the otherness of the 'world', one part of which is the 'body', which provides the basis for the 'mind', and so on ...

"Minds awaken in the world. We did not design our world. We simply found ourselves with it; we awoke both to ourselves and to the world we inhabit. We come to reflect on that world as we grow and live. We reflect on a world that is not made, but found, and yet it is also our structure that enables us to reflect upon this world. Thus in reflection we find ourselves in a circle: we are in a world that seems to be there before reflection begins, but that world is not separate from us."

(Varela, Thompson & Rosch, 1991, p. 3)

They term this a "fundamental circularity" affecting all investigations of cognition. The "mind" reflecting on the world is itself dependent on its embodiment or structure (its biological base). Any knowledge of that structure is mediated by this same "mind". Another way to describe this is that any categorical statement about "the world" and / or "the mind" is made by an enquirer (observer), who remains outside the scope of the enquiry. This "standing apart" excludes the observing enquirer from the phenomenon she studies, even though her enquiry is conducted on the basis of that selfsame phenomenon.

Varela *et al.* proceed from the assumption experience necessarily predates and underpins enquiry. To overcome the "fundamental circularity" requires an explanation for lived experience to form a coherent foundation for description of mind, world (as experienced), and the relation(s) between them -- not the other way around. Maintaining a focus on experience as action allows inspection and reflection on the manner in which "mind" and "body" reciprocally engage to consummate experience.

Enactive Cognitive Science

The cognitivist and connectionist paradigms remain subject to the theoretical limitations outlined earlier. As a result, Varela, Thompson and Rosch suggest creation of an **enactive cognitive science** which:

Addresses commonsense action by...

> "...treating context-dependent know-how not as a residual artifact that can be progressively eliminated by the discovery of more sophisticated rules but as, in fact, the very essence of creative cognition."
>
> (Varela, Thompson & Rosch, 1991, p. 148)

Embraces the hermeneutic viewpoint that...

> "...knowledge depends on being in a world that is inseparable from our bodies, our language, and our social history -- in short, from our embodiment."
>
> (*Op. cit.*, p. 149)

Denies epistemological absolutism by acknowledging...

> "...knowledge is the result of an ongoing interpretation that emerges from our capacities of understanding ... rooted in the structures of our biological embodiment but ... lived and experienced within a domain of consensual action and cultural history."
>
> (*Op. cit.*, p. 149)

Admits cognition is embodied action, in which...

> "...cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities ... themselves embedded in a more encompassing biological, psychological, and cultural context."
>
> (*Op. cit.*, p. 173)

To Summarize:

Varela, Thompson and Rosch (1991) outline what they see as the problematical positions evidenced in the dominant cognitive science paradigm (**cognitivism**) and the recently ascendant interest in **connectionism**.

They outline their **enactive perspective** as a third alternative, contrasted with the other two.

To Explore More Deeply...

Because the definition of enactive cognitive science is accomplished primarily through comparisons and contrasts with the other two paradigms, it is best explained in the same manner. I have prepared two tables presenting the general and the specific comparative analyses presented in *The Embodied*

Mind. The first (**Table ECS1**) offers a summary overview of the three cognitive science traditions. The second (**Table ECS2**) provides a summary of how these three traditions address the key questions which the authors delineated as the criteria for cognitive science as a coherent explanation.

These tables are available on the Enactive Cognitive Science in Context Focus File page here at *The Observer Web.*

http://www.enolagaia.com/ECSTables.html

Summary

Autopoietic theory provides a rigorous theoretical basis for addressing humans and the social systems in which they participate.

Because the theory proceeds from formal specifications on systemic unities, its tenets can conceivably be applied to both.

Owing to the extent of Maturana and Varela's expansion of the core concepts to describe a phenomenology of living systems, the theory's scope is relatively broad. This permits researchers to apply its principles across a broader range of subject phenomena than is the case for other current approaches.

Because it is rooted in a formal analysis of living systems and cognition, the theory can support research focusing on individual subjects and their activities within an enterprise (e.g., workflow analyses, human factors / HCI analyses of specific information system users).

Because the theory includes an explanation for linguistic interaction, it can support research focusing on enterprise social interactions and communications (e.g., ethnographic studies; qualitative research).

The more recent focus on *enaction* initiated in *The Embodied Mind* has moved autopoietic theory's focus forward from formal models to dynamic phenomenology.

Having completed this overview, it should be clearer to you how autopoietic theory intrinsically supports attention to the three emergent themes in current studies of cognition, interaction, and social systems:

- systemic perspective,
- auto-determination, and
- contextualization.

The first occurs by definition, the second by focus, and the third by the manner in which Maturana and/or Varela lay out the phenomenological aspects of the theory.

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presentation of the material in its original format. Because this paper is very difficult to obtain in the form of its original BCL Report, it is primarily known via its appearance in *Autopoiesis and Cognition*. As a result, I have formatted the BCL Report document to reflect the pagination of its appearance in that 1980 book. This allows you to reference and cite the material with respect to the book's page numbers.

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The volume in which it was published is a hard-to-find collection of papers given at a conference in April 1978 on the theme of 'The Theory of Autopoietic Systems as a New Foundation for the Social Sciences'. All the papers are in German, with the exception of Maturana's contribution, entitled 'Cognition'. It is a very concise article on issues of cognition, making it a highly-recommended paper for the beginner (if he/she can find it).

This paper is now available as an *Observer Web Archive Edition* -- formatted to faithfully replicate the layout and pagination of the original publication. You can access it here at *The Observer Web*:

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