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The Process of Knowing: A Biocognitive Epistemology

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The biocognitive theory presented in this paper offers an alternative to the attribution of cause perpetuated by the life sciences in our western culture. Historically, biology has based its epistemology on physics to understand life, whereas cognitive science has grounded its ontology in a convergence of biology, physics, and philosophy to provide models of self that range from a passive acceptance of an outside world to the active creation of an inner world. While Newtonian physics has served us well in the physical sciences, the life sciences continue to embrace the limitations of its reductionism without advancing to the more inclusive concepts offered by complexity and quantum theories. As long as the biological and cognitive sciences remain married to Newtonian physics and Cartesian philosophy, mind will be relegated to an epiphenomenon of biology that will continue to separate cognitive processes from biological functions. Rather than choosing between upward causality that explains cause from the simplest level of the organism and downward causality that explains it from the most complex to the simplest, biocognitive theory offers *contextual coemergence* where the simultaneous resonance between fields of bioinformation is the genesis of cause. In this model of coemergent causality, cognition, biology, and cultural history are viewed as *biocognitions* that communicate within a bioinformational field that has both linear processes in Euclidian geometry and non-linear processes in fractal geometry. Because of the simultaneous and reciprocal nature of mind and body communication, it is argued that *biology creates thought and thought creates biology*. Just as mind and body cannot be separated, to attempt a separation of mind and world would create an artificial split between observer and observation that assumes we can "step out" of the world we are attempting to observe.

Any theory that attempts to define the process of knowing requires an explanation of how information is accessed, stored, and retrieved in order to understand how learning takes place. In the biocognitive theory presented here cognition, biology, and historical culture are viewed as *inseparable processes that coemerge in a bioinformational field to contextualize a biocognitive reality* (Martinez, 1999). This falls against a reductionism that defines cognition

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as an epiphenomenon of biology and a dualism that separates mind and body. Proposed instead is an epistemology of *biocognition* as composed of thoughts, emotions, and language that evolve from a historical culture where the components *coemerge* rather than originate from one or the other. This assertion, however, does not imply that thoughts, emotions, and language coemerge and develop with parallel complexity. Instead, it converges theories that suggest: (1) cognition begins in infancy with perceptions of undifferentiated personal space and time (i.e., undefined boundaries between self and surroundings without time discernment), (2) emotions evolve from sensations of comfort vs. discomfort and security vs. insecurity and, (3) language evolves from primordial sounds that express sensations related to undifferentiated internal and external stimuli. Bioinformation is defined as *the cognitive, biological, and historical culture that individuals contextually share in their communication.* In other words, bioinformation is exchanged history between coemerging fields that seek contextual relevance. Within this exchange of histories, *contextual relevance* is defined as *the best fit between function and purpose that an organism or event can achieve in a given context.* The model of *emergence* supported by traditional life sciences is insufficient to reflect how we process information in particular, and how cognition, biology, and cultural history interact in general. The proponents of emergence suggest that new components of an organism "surface" as aggregates without considering contiguous contexts that interact with the organism. The surfacing concept is applied in the life sciences to explain how organisms develop and how knowledge is acquired. The contiguous context *coemerges* in the development and acquisition of information: an organism and its contiguous context are inseparable and reciprocal in the process of development. Biocognitive theory is grounded on the premise that one cannot create context without creating contiguous contexts. Even vacuums create contiguous contexts that embrace their boundaries. Thus, the construct of emergence is insufficient to explain the processes of development and of knowing because emergence neglects the coauthoring contributions of contiguous contexts.

The Biocognitive Acquisition of Language in the Process of Knowing

Although biocognitive theory is consistent with the co-evolution and *autopoiesis* hypotheses of Maturana and Varela (1992), I reject Maturana's (1997) postulate that knowledge is a biological phenomenon and can only be studied as such. While Maturana's contention that cognition resides in biology is correct as a teleological inference (i.e., cognition evolved from a biological design), he erroneously concludes that origin equals cause. Although homo sapiens have a biological genesis, it does not follow that cognition can be explained from an exclusively organic process. It is here argued that cog-

nition, biology, and historical culture are inseparable components of coemergent causality and that knowing occurs as biocognitive *contextual events* that begin in infancy as precursors of thought, emotion, and language. Knowledge progresses through three developmental phases defined as pre-linguistic, concrete-linguistic, and abstract-linguistic experiences. The pre-linguistic phase consists of precursors of thoughts (perceptions of undifferentiated personal space without time dimension); precursors of affect (sensations of comfort and security vs. discomfort and insecurity); and precursors of language (primordial sounds responding to undifferentiated internal and external stimuli). The concrete-linguistic phase advances from precursors of thought to a cognition that differentiates self from non-self in concrete time and space; from the sensations of comfort and discomfort to the emotions of happiness, sadness etc.; and from primordial sounds that respond to undifferentiated internal and external stimuli to language that represents simple imagery and emotions communicated in concrete space and time. The abstract-linguistic phase frees the knower from the limitations of concrete-linguistics with language that can communicate complex imagery and emotions in projected time and space. The knower can project time and space from the present to communicate about the past and the future as abstract entities separate from self. The abstract-linguistic phase introduces cognition of abstract rules (multi-contextual) that represent complex behavior (e.g., morals) as well as complex emotions that allow self to identify affectively with others (e.g., empathy and love). While biocognitive theory is consistent with Wilber's (2000) contention that a comprehensive theory of knowledge must include a transcendental phase, such level of inquiry is beyond the scope of this paper. Wilber's integrative model presents operational differences between delusional and transcendental experiences.

Knowing begins with undifferentiated perception of personal space and time along with undifferentiated sensorial reactions to internal and external stimuli. With the acquisition of language, formulations of self and non-self coemerge as differentiated entities that are stored, recalled, imagined, and communicated with maximum contextual relevance. Since, during the precursor stage, thoughts, emotions, and symbolic language are not fully functional, the process of knowing is limited to learning pre-linguistic visual-spatial contextual relevance. Although cognition cannot occur without conceptualizing procedures, during the precursor stage the infant learns visual–spatial contextual relevance to create a foundation that can facilitate conceptualization when language is acquired. *Perception is the sensorial recognition of contextual relevance and cognition is the language that can conceptualize the perception.* For example, although an infant cannot differentiate personal space, he or she can recognize and can respond to the contextual relevance formatted by the coemergence of hunger, the mother's face, and her breast. The visual–spatial

contextual relevance progresses from the recognition of form, self, and others to conceptualizing differential relationships. In the process of knowing, bioinformation is selected, stored, and retrieved as contextual fields of inseparable cognitive, biological, and cultural parameters. These bioinformational fields are *decontextualized* from linear to non-linear space during storage and *recontextualized* from non-linear to linear space during retrieval.

Biocognitive theory differs from other models of cognition in how information is processed, stored, and retrieved as well as how cause is determined. Cognition and biology occur simultaneously as a *biocognition* within a context of cultural history that can only be separated "artificially." Rather than originating (emerging) from any of its components (cognition, biology, and culture), knowing *coemerges* in a bioinformational field that constantly seeks contextual relevance. The components can be artificially separated only *after* they are experienced and the separation can only yield *heuristic* data about an experience. Bioinformation is stored in *non-linear* space as cognitive, biological, and cultural *recontextualizing procedural traces* and is retrieved as inseparable biocognitions that coemerge to meaning triggered by contextual relevance in linear space. In other words, bioinformation is not stored and retrieved symbolically as suggested by connectivism. Instead, it is *impressed* non-linearly as traces of biocognitive procedural parameters (i.e., recontextualizing rules) that coemerge to expression as a function of the *contextual relevance* imposed by the field.

Biocognitions are *decontextualized* into procedural traces during storage and are *recontextualized* into biocognitions during retrieval. The traces are *fractals* that contain all the procedural rules required to recontextualize bioinformation with maximum contextual relevance during retrieval. Fractals contain all of the bioinformation of the entity or event. The *bioinformational field* is conceptualized as a non-linear *phase space* where biocognitive contexts are destabilized into procedural traces during storage and re-stabilized into new contexts during retrieval in linear space by the process of *contextual coemergence* (see below). Bioinformation is *expressed* linearly and locally through the nervous, endocrine, and immune *pathways* in a space of Euclidian geometry, and is *impressed* non-linearly and non-locally in a space of fractal geometry in the totality of the field (i.e., all cells in the organism). Health and illness are neither exclusively biological nor totally mental. Consequently, all human processes are biocognitions that coemerge rather than emerge from their components and are inseparable from their contextual relevance.

Contextual Coemergence

Most western models of mind range from the passive acceptance of an outside world to the active creation of an inner world. These models maintain

an artificial separation between observer and observation that assumes we can "step out" of the world we are attempting to observe. Consequently, the impossibility of separating biology and cognition from their cultural history also applies to mind and world. The observer has a biocognitive history that coemerges with the history of the world that is being observed. Contextual coemergence is a concept where the observer, the process of observing and the observation are inseparable, and the illusive "stepping out" of that space can only offer heuristic data about the totality of the experience.

It should be noted that the biocognitive concept of coemergence is difficult to grasp or accept when it is conceptualized by assumptions about causality that traditional philosophies of science make. In particular, biological theories are grounded on reductionistic models of upward causality where organisms are studied from their simplest to their most complex structures. The field of psychopharmacology, for example, attempts to understand "mental" pathology through neurochemistry. Conversely, alternative medicine looks for the origin of "biological" pathology in cognitive processes.

While both approaches are necessary to understand pathological processes, neither provides the complexity required to capture the coemergent causality that takes place when cognition, biology, and cultural history contextualize health and disease. The reductionism of upward causality and the expansionism of downward causality fail to resolve the dualism inherited from the Cartesian mind–body model that views organic and mental processes as separate entities where one originates from the other. Consequently, this dualism promotes the idea that if mind, body, and culture can be separated, they can also be extracted from their contextual relevance. Varela, Thompson, and Rosch (1992) have correctly argued that traditional cognitive science *disembodies* "self" by excluding the phenomenology of an observer from the dynamics of an observation. Additionally, traditional philosophies of science are formulated within a conceptual space of Euclidian geometry that does not allow for non-linear processes. Clayton and Frey (1996) propose a fractal model (non-linear geometry) of visual memory that suggests information is stored as a set of reconstructing procedures that are activated during retrieval. They treat remembering and imagining as processes governed by *iterative rules*.[1]

The concept of contextual coemergence transcends the limitations of dualism and reductionism inherent in linear processes. Rather than assign cause to the simplest or the most complex levels of an organism or event, cause is attributed to the simultaneous contributions of fields. The contextual coemergence process includes both linear and non-linear communica-

[1]Iteration is defined in chaos theory as repeated self-similarity within fractal geometry. A form that repeats itself as it expands in multiples of its original shape.

tions with local and non-local events — in contextual coemergence, cognitive, biological, and historical culture communicate linearly with locality through the nervous, endocrine, and immune pathways and is expressed in *manifest portals* throughout the body. For example, an interpretation that triggers an acute stress reaction is expressed through the nervous, endocrine, and immune pathways and is manifested in the cardiovascular or gastrointestinal portals. At the same time, the communication is impressed instantaneously, nonlinearly, and non-locally, in the totality of the field (i.e., all cells in the body). This simultaneity of linear and non-linear spatial states with local and non-local properties is the bioinformational process that communicates, stores, and retrieves biocognitions within fields of coemerging contexts.

Linearity and locality. In linear space, movement from point (*a*) to point (*b*) occurs sequentially (one point in space at a time) at less than the speed of light (Einstein's constant) and the traveling entity or event (information) maintains its original form. Additionally, the trajectory of the movement can be traced and predicted with linear models. A violation of locality occurs when an entity or event appears to travel faster than the speed of light creating a sense of instantaneousness. Since it would be unacceptable to violate the limits of Einstein's constant, the event is conceived as not having "traveled" from points (*a*) to (*b*) but occurring *simultaneously* at both points (Bell, 1965).

However, there are events that occur in the laboratory and in nature that appear to violate the rules of linearity (Lorenz, 1963) and of locality (Bohm, 1980). The non-linear processes (e.g., formation of clouds) cannot be predicted with linear instruments because these chaotic configurations occur within a space of fractal geometry (Mandelbrot, 1977). When an event or entity shifts chaotically from the order of linear space to the disorder of non-linear space (chaotic state) the form or information of the event *bifurcates* into traces (fractals) that maintain the original form or information of the event in each of the traces (i.e., iteration). Conversely, in linear space, when fragmentation occurs each trace contains only the form and information of that trace. Although non-linear and non-local events are accepted concepts in complexity (chaos) and quantum theories respectively, these concepts remain absent in the epistemology of the biological and cognitive sciences. Nevertheless, there is an emerging research interest in the applications of chaos and non-local principles to cognitive and biological processes (e.g., The Society for Chaos Theory in Psychology and the Life Sciences). To cite a practical example: when an event is interpreted as aversive, the alarm triggers a linear sequence of stress hormones (CRF, ACTH, cortisol etc.) through the nervous, endocrine, and immune pathways that are expressed in

manifest portals (e.g., increased heart rate, muscle tension etc.) and the effect of the interpretation is also impressed non-linearly as an instantaneous (non-local) alarm potential in the totality of the field (i.e., all cells). The impressed alarm potential is triggered to expression in the course of knowing as new contexts of alarm coemerge in a process that attempts maximum relevance in the bioinformational field. Thus, the totality of the organism has a potential to respond with a stress reaction when confronted with contexts that make stress relevant.

A chronic state of alarm triggers continuous linear stress responses through the nervous, endocrine, and immune pathways and simultaneously creates a *stress impression* in the bioinformational field. When repeated patterns of alarm are chronically impressed in the field, these patterns predispose stress configurations that unwittingly perpetuate dysfunctional contextual relevance by responding with stress when confronted with benign experiences. While functional processes seek contextual relevance that resolves stress, chronic states of alarm find contextual relevance in the repetitive patterns that maintain stress. Although both stressful and benign experiences are interpreted locally through the nervous, endocrine, and immune pathways, *all* experiences, independent of their interpretations, are biocognitions of coemerging cognitive, biological, and cultural history parameters that are also impressed non-locally in the bioinformational field. Since linear knowledge cannot exist without context and we cannot evolve without knowledge, entropy is defined as a *progressive complexity of mind, body, and cultural parameters that seek contextual relevance* (i.e., meaning) *in a field of constant oscillation between stability and chaos.*[2] Thus, *to know is to recognize contextual relevance.* Homo sapiens evolved from the simplistic Darwinian survival instincts toward the pursuit of meaning when consciousness coemerged as the observer of our journey and the judge of our actions. Behavior could no longer occur without justification. Since mind has to contextualize meaning in a seamless world, the observer erroneously assumes that context emerges as a separate entity from an observation. This seamless world is formulated as a field with infinite contextual possibilities that are triggered to expression by the coemergence of observer and observation. While *emergent causality* is derived from one event *reacting* to another, *coemergent causality* is based on the *coaction* of events. The appearance of action/reaction occurs because the engagement of contexts takes place simultaneously but is perceived sequen-

[2]This statement only applies to the linear processes of knowing without denying the consciousness without context achieved in transcendental states during deep meditation. The level of meaning derived from those states is described as very similar to what we commonly call intuition.

tially. Just as Bohr's (1934) theorem of *complementarity* accommodates the dual nature of light — photons have both wave and particle characteristics — coemergent causality includes both sequential and simultaneous processes where the sequence is perceived after the simultaneous engagement takes place.[3]

Belief Fields and their Horizons

While bioinformation links cognition and biology in a cultural history, our apprehension of an experience requires decisions that define the boundaries of the experience. These decisions are commitments to what is accepted as self vs. non-self and the relationship to the other. Consequently, a *belief is defined as a commitment to how a biocognition is contextualized.* Merleau–Ponty's (1962) concept of *internal* and *external horizons* is extrapolated to delineate the coherence and relevance of the biocognitive *belief fields.* A biocognitive event has internal horizons that define the internal coherence of that event across different contexts. Internal horizons preserve the biological (form), cognitive (percept), and cultural (shared beliefs) integrity of the organism or event across contexts. Without internal horizons there would be no coherent definition of entities. While the internal horizons maintain internal coherence, the external horizons define the contextual relevance of the event or organism: the internal horizons define the entities and the external horizons determine the relative functions of the entities. Internal and external horizons are operational from the molecular to the cognitive levels, that is, in all biocognitions. For example, cells as well as thoughts have internal horizons that define the boundaries of their entities and external horizons that define contextual relevance across contexts: *cause is the event that takes place when the external horizons of contexts coemerge.* Thus, bioinformation coemerges contextually because a unit of knowledge cannot exist without boundaries. Just as one ponders that if the universe is infinite there can be no boundaries, the opposite is true in contextual coemergence — there can be no context without boundaries (horizons) or no boundaries without contiguous contexts. This inevitability of contextual contiguity is the basis of coemergence. It should be noted however, that if the universe is seamless, then context is a creation of our perceptual parameters reflecting our idiosyncratic limitations.

[3]Although *complementarity* is a quantum theorem applied to subatomic particles, Bohm (1980) argues that matter and energy in general and consciousness in particular also behave with an apparent dual causality he calls implicate and explicate order.

Historical Culture in Bioinformation

Knowledge is acquired, stored, and retrieved as inseparable mind, body, and cultural history fields of bioinformation. The contributions of cultural history are differentiated from the concept of society. Culture is defined as the *internalized ethical, scientific, and transcendental beliefs that a group shares*, while society is *the external rules of behavior that control a group*. A compelling example of this differential is illustrated in how Spain was able to maintain cultural integrity after several centuries of Arab domination (711–1263) while acquiescing to the social rules during the siege. It should be clarified that culture is not an inflexible dictum that uniformly shapes a reality across individuals. More accurately, culture is group idiosyncrasies that are assimilated through interactions with personal history. Although once assimilated, *biocultural* beliefs are rather stable across environments, these beliefs continue to be influenced by future personal experience as well as by exposure to other cultures.

As social rules become more oppressive, cultural beliefs become more consolidated and more resistant to change. Societies that respect the integrity of their subcultures facilitate acculturation and benefit from shared idiosyncratic wisdom. There is ample evidence in medical anthropology research to indicate that biocultural beliefs are a significant variable in the modulation of health and illness (Romanucci–Ross, Moerman, and Tancredi, 1997; Sargent and Johnson, 1996; Scheidt and Windley, 1998). Assimilated biocultural parameters interact with socio-economics to determine how the *biology of disease* is translated to the *anthropology of illness* by the medical or healing culture. In other words, *disease is the observable pathology of an organism* and *illness is the biocultural interpretation of the symptoms*. Traditionally, disease is identified through a reductionism that finds pathology at the lowest biological level of the organism (molecular, cellular, histological etc.) without considering that the pathology takes the name of an illness based on the internalized scientific or healing beliefs of the bioculture.

Payer (1996) illustrates in her comparative review of medical practice in the United States and Western European countries how the etiology of a migraine is vascular in the United States, hepatic in France, and gastrointestinal in Britain. Additionally, while hypotension is a predictor of longevity in the United States, in Germany hypotension is diagnosed as a pathological condition called *Herzinsuffizienz* (cardiac insufficiency).

In the Bolivian subculture that includes Aymara Indians, *Mestizos* (half White and half Indian) and Whites, western-trained physicians diagnose the disease that causes a deficiency in the oxygen-carrying component of hemoglobin as anemia (i.e., the cultural name of the illness) for Whites and Mestizos. But if the Aymara Indians were diagnosed with the same disease (pathological manifestations), the Aymara shaman (*yatiri*) would name the

illness *limpu* and would offer a different etiology. More strikingly however is the influence biocultural beliefs have on prognosis. If a White or a *Mestizo* is diagnosed with anemia, the disorder is treatable within the western medical culture. If an Indian is diagnosed with anemia by the western-trained doctor and then conceived as *limpu* by the shaman, the Indian will most likely die because of the biocultural fate given to that illness by the Indian healing culture.[4] Additionally, the *Mestizo* is protected from the label and fate of *limpu* as long as he or she remains socio-economically compatible with the White and superior to the Indian. If the socio-economics of the *Mestizo* drop (as happened with the agrarian reform in Bolivia in 1952), the previously immune *Mestizo* can become vulnerable to *limpu*/anemia and if afflicted will most likely acculturate to the lethality of the illness independent of medical diagnostics (Crandon-Malamud, 1997).

Crandon–Malamud (1997) documents a case of an elderly Aymara Indian who was diagnosed with *limpu* by a shaman and after struggling with the biocultural implications of the illness, the afflicted Indian visited a western-trained physician who diagnosed him with anemia but was otherwise seen as in good health. The elderly Indian, however, died twenty-four hours after visiting the physician — believing he had *limpu*. While other causes of death could not be ruled out, the *limpu*/anemia biocultural beliefs appear to have influenced the course of the illness.

Crandon–Malamud (1991) also describes six cases of *Mestizo* youths in their late teens and early twenties who suffered from similar severe illnesses with both nutritional and psychological etiologies. All six came from families who had experienced significant downward mobility and were now among the poorest in their village. The first four were treated with Western medical and psychiatric therapies based upon village consensus that the youths suffered from scientifically identified disorders. After all four died from their illnesses however, the remaining two youths turned to Aymara shamans and most villagers concurred that both youths suffered from "Indian" illnesses. The last two youths survived after receiving treatment from the shamans. It should be noted that the two survivors were siblings of two of the four youths who died after being diagnosed and treated for similar illnesses within a Western medical model.

The biocultural beliefs that shape the diagnosis of an illness and the shifts in socio-economic status may have an interactive influence on prognosis. Hahn and Kleiman (1983) argue that expectations about prognosis are not merely propositions about outcome — they are cognitions reflected in the

[4]*Limpu* is considered a fatal illness caused by the spirit of a stillborn who, having died without baptism, is denied entrance to heaven and has to consume to death the body of the afflicted in order to continue to exist on earth.

biology of those who assert them and are thus associated with neurotransmitters and hormones that affect physiology. Hahn (1995) cites cross-cultural variations in placebo effect from a meta-analysis conducted by Moerman (1983) of thirty-one studies carried out in sixteen different countries on the efficacy of Cimetidine for relief of gastric and duodenal ulcers. All the studies were double-blinded and all reexamined treatment and control patients for the presence of ulcers after four to six weeks. Out of the total thirty-one groups, only thirteen showed a statistical difference in outcome. Additionally, one of the studies reviewed by Moerman (Sonnenberg, Kleine, and Weber, 1979) found that ulcers recurred in 48 percent of patients treated with Cimetidine, but ulcers recurred in only nine percent of the patients treated with placebos. Moerman also noted variation in the efficacy of the placebo from country to country with Germany having the highest rate of placebo healing (63 percent).

Just as Gould and Eldredge's (1977) concept of *punctuated equilibria* considers geographic factors as contributors to the abrupt appearance of new species, here culture is conceptualized as the "geographic" variable in the ontogenesis of biocognitions. According to Gould and Eldredge, punctuated equilibria illustrates how a species can emerge abruptly after millennia of minimal change in contrast to the Darwinian principle of gradual adaptation. One might argue that in the process of knowing, bioinformation includes abrupt ontogenetic contextual shifts as well as gradual adaptive evolutionary steps. In the traditional biological model of emergence, one must attribute upward or downward causality to an event and then decide whether knowing is evolutionary or developmental. In biocognition however, causality coemerges and the process of knowing includes evolutionary (genetic) characteristics as well as developmental (co-designing). Medical anthropology has documented cultural influences on disease while the interdisciplinary field of psychoneuroimmunology (see Ader, Felten, and Cohen, 2000; Solomon, 2000) has elegantly investigated the bi-directional communication between biological pathways and cognitive states. Within both disciplines *cognition and biology coauthor personal reality in a cultural history that affects health and illness*. This formulation, of course, does not deny genetic or environmental influences.

Bioethical Codes and Their Modulation of Health and Illness

The rules of conduct that formulate and modify our beliefs are presented as *bioethical codes* with cognitive and affective parameters (influences) that are assimilated from our historical culture.[5] The contextual commitments we

[5]Bioethical codes are cultural rules of conduct that are interwoven with our biology rather than the conventional philosophical term (bioethics) that defines what is moral medical practice.

make to frame our beliefs are interpreted by bioethical codes that have biocognitive consequences. The bioethical codes, like all bioinformation, are interpreted linearly by the nervous, endocrine, and immune pathways; expressed linearly through manifest portals; and impressed simultaneously in the totality of the field. The linear and simultaneous interpretative processes that result from the coemergence of self and environment modulate health and illness through a constant oscillation from stable to unstable contexts. In this process of coemergence, memory is impressed instantaneously (nonlocally) in the totality of the field (all of the organism) and is expressed linearly (locally) through the nervous, endocrine, and immune pathways as well as other manifest portals (e.g., skin, organs, thoughts). Although memory is archived through brain processes, bioinformation is also impressed throughout the entire body — which supports Varela's contention that the "mind is not in the head" (Francisco Varela, personal communication, October 6, 2000).[6] To provide heuristic as well as operational components that may explain how cognition and affect define and expand our beliefs, Martinez (1999) posits three bioethical codes — rules of conduct assimilated from our cultural history.

A *gatekeeper code* is proposed as the cognitive and affective rules that determine the external horizons of a belief field and define what is self and non-self. The horizons of the code are maintained cognitively with expectations of reduced safety and affectively with fear. The cognitive–affective parameters of the gatekeeper code serve to maintain self within known territory and to signal when the boundaries are reached. If the gatekeeper parameters fail to maintain field coherence, an *enforcer code* is activated to address the violations of horizons using more aversive cognitive–affective controls. Transgressions are dissuaded cognitively with expectations of dangerous outcome and affectively with volatile emotions. In order to assimilate new information, however, a *pioneer code*, through the expression of our most evolved cognitions and emotions, serves to expand the horizons of the belief field. The cognitive–affective composition of the pioneer code facilitates the acquisition of knowledge by replacing entrenchment with discovery. The expansion of horizons occurs cognitively through faith (i.e., action with propitious expectations) and affectively with empathy and compassion. Faith in this treatise does not refer to a religious belief, but rather to a commitment to ideal expectations or to expectations where the actual outcome will be perceived as the most propitious. The bioethical codes define, regulate, and expand a belief field in the process of knowing. The cognitive–affective modes of each bioethical code have differential effects on the external horizons of a belief field. While the cognitive–affective components of the gate-

[6]At the time of this communication, F. Varela was finishing his book titled *Lived Body: Why the Mind is not in the Head.* Sadly, Dr. Varela passed away in May 2001. The book remains unpublished.

keeper and enforcer codes define and impose entrenchment on the external horizons respectively, the pioneer code's function is to expand the external horizons and facilitate the ontogenesis of a belief field.

The Coemergence of Context in the Bioinformational Field

Bioinformation is stored as non-linear fractals of cognitive, biological, and cultural parameters with a potential to recontextualize based on the relevance of the retrieval.[7] Rather than storing and retrieving *information* as associative or representational data, and rather than dividing the process into cognitive and biological memory, bioinformation is archived as cognitive–biological–cultural fractals with recontextualizing procedural rules that are activated during retrieval. The contextual relevance imposed by the fields determines how the archived non-linear fractals are recontextualized into linear space.

Research in the life sciences demonstrates the presence of non-linear systems in biological processes ranging from cardiac rhythms (Goldberger, Bhargava, and West, 1985; Winfree, 1987) to nervous system pathways (Freedman, 1994). Additionally, researchers in cognitive science have employed non-linear models to study a myriad of mental processes (Combs, 1996; Orsucci, 1998). Contextual relevance occurs when the external horizons of a bioinformational event collapse from non-linear instability (bioinformational uncertainty) to stable linear coherence (meaning). This process holds true from the simplest level of an organism to the most complex. Thus, the external horizons of cells as well as of consciousness are unstable in the pre-contextual stage and stabilize when they resonate with other external horizons to achieve contextual relevance. In the case of a cell, the contextual relevance is defined by the biological function of the cell in relation to its organic context, whereas in consciousness relevance is defined by the cognition required to achieve meaning in the process of knowing.[8]

Rather than storing bionformation in a linear space as symbols that reflect an event or the context in which an event takes place, bioinformation is stored through a chaotic process (i.e., deterministic disorder) that destabilizes the external horizons of a field in non-linear space. The instability of the external horizons decontextualizes an event and stores it as traces of pro-

[7]Context is stored as decontextualized fractals with all the bioinformation of the context as well as the procedural rules to recontextualize the bioinformation during retrieval. Rather than predetermined rules, the procedures are contextual potentials brought to meaning by the relevance that a field imposes on the retrieval.

[8]Although, while illustrating these processes there appear to be separate descriptions of cognitive and biological entities, these are merely heuristic illustrations to conceptualize the components of biocognition rather than reverting to the dualism biocognitive theory is attempting to transcend.

cedural parameters (fractals) that can recontextualize the event based on the contextual relevance imposed by the retrieval process. Storage and retrieval are accomplished through an oscillation from stability to instability that decontextualizes and recontextualizes the external horizons of fields. Thus, a biocognitive event is decontextualized for non-linear storage and recontextualized for linear retrieval. It is important to note that this process of storage and retrieval should not be confused with objectivist models that conceive form as accumulated fragments nor with the constructivist theories that construct and reconstruct context linearly. The acquisition of knowledge is conceptualized differently than with customary linear theories. While according to objectivism, constructivism etc., "information" is conceived as representations that are accessed, stored, and retrieved exclusively through linear processes within Euclidian geometry, here bioinformation is conceptualized as procedural parameters of inseparable cognition, biology, and historical cultures that *oscillate* as *biocognitions* from linearity in Euclidian geometry to non-linearity in fractal geometry. Thus, coemergence of bioinformation includes both linear sequencing and non-linear instantaneousness.

Space in the Bioinformational Field

The bioinformational field includes both linear and nonlinear processes within Euclidian and fractal geometries respectively. Both are required to contextualize and decontextualize information from stable linear horizons to unstable (chaotic) non-linear horizons. External horizons are destabilized when confronted with new information that is attempting to coemerge toward novel contextual relevance or when information needs to be archived in memory. Destabilization is required to decontextualize the external horizons in order to achieve coemergence with other fields. When external horizons destabilize, they shift from order in linear space into disorder in non-linear chaotic space. Bioinformation decontextualizes into fractals that — while becoming traces of the whole — maintain all the bioinformation of the whole. Examples of this self-similarity replication, also known as *infinite nesting*, include the branching patterns of roots, the electrical trajectories of lightning, and some configurations of the human vascular system (Hall, 1994). In fact, iteration is more the rule than the exception in organisms and nature (Gleick, 1988).

Just as context in linear space requires boundary definition, events in non-linear space require limits to contain the chaotic process. In chaos theory, the interaction of internal and external variables that contain disorder in a non-linear process is called *strange attractors*. For example, when water is spilled on a hardwood floor the spill creates patterns that are not predictable with linear models and, although the patterns appear random, the resulting

shape is determined by a multitude of unstable variables that interact in unison to create the strange attractors that contain the chaos. Just as strange attractors contain chaotic processes, unstable horizons contain novelty in the process of knowing. During the unstable state, bioinformation operates at the pre-meaning stage (precursor of context) until the stabilization of horizons creates contextual meaning. For example, in the process of solving a problem, there is a state of "suspension" (disruption of linear thinking) just before the solution is reached. The precursors of thought in early developmental stages exist in a chaotic state where their instability precludes reaching the contextual meaning required to differentiate self vs. non-self, sensations vs. feelings, and sounds vs. language. Sabelli (2001) found what he calls *biotic patterns* in natural processes such as heartbeat intervals that, although chaotic in their nonlinear nature, show complex *novel patterns* rather than unpredictability. Thus, self-generating systems such as living organisms continually create novel and transient patterns that diversify in time. Brain activity may oscillate from *novelty chaos* to linear stability in the process of accessing, archiving, and retrieving bioinformation.[9]

In turn, the range of contextual possibilities that coemerge in a field is conceptualized within a *phase space*. Phase space describes the infinite possibilities that exist within a finite space contained by strange attractors. In the life sciences, the phase space of an organism is contained by horizons that are determined by the species-specific limitations of the organism as it interacts with novel contexts. For example, a person can respond to an event (context) with infinite behavioral strategies that are restricted only by the cognitive, biological, and cultural limitations (horizons) of homo sapiens. If the event happens to be threatening, options to escape potential danger — although theoretically infinite — do not include flying away, as a bird can very easily do. Conversely, the phase space of a bird does not include the option to verbally negotiate a dangerous situation. However, the observer, the observing, and the observation coemerge to achieve contextual relevance as processes rather than as components. Consequently, coemergence can only be "dissected" in abstraction to gain heuristic knowledge about an inextricable context.

Bioethical Codes in the Bioinformational Field

A belief field is a biocognitive construct that defines personal reality through cognitive assumptions and affective feedback. Personal and cultural histories serve as the known data that allow us to make suppositions under unknown

[9]The concept of *novelty chaos* is introduced here to differentiate the biotic patterns of living processes that generate novelty from other chaotic patterns that generate unpredictability (Sabelli, 2001). It appears chaotic patterns of living processes are not contained by strange attractors.

circumstances. A *cognitive–affective–cultural* field of biocognition is guided by bioethical codes that define, regulate, and expand the field's external horizons.

Rather than mere semantic shuffling, the language of chaos theory can facilitate the conceptual navigation of the field as the cognitive–affective parameters of bioethical codes modulate the external horizons through chaotic processes. The gatekeeper code may trigger turbulence at the external horizons that is resolved when attempts to explore beyond the familiar cease. If the turbulence is not strong enough to maintain the horizons, the aversive effect is intensified by the executor code. In other words, if fear fails to dissuade risk-taking, fear is replaced with more prohibitive emotions to restrain our exploratory behavior. There must be a process, however, that retains the expansion needed to evolve from mere exposure to new experiences. Following the logic of how the gatekeeper and executor codes maintain entrenchment of external horizons by preventing stability beyond defined limits of the field, the cognitive–affective components of the pioneer code must offer a process that can overcome the impasse. Cognitions of propitious expectations (i.e., faith) combined with emotions of empathy and compassion, facilitate exploration beyond the entrenched external horizons, and allow retention of the expanded horizons. Since the pioneer code replaces the aversive cognitions and emotions of the gatekeeper and executor codes with benign expectations coupled with affect that identifies positively with the expanded space, one could assume that the instability caused by the expansion of horizons is resolved, preventing a return to the previously entrenched external horizons. Thus, an expansion of external horizons with aversive interpretations is temporary, whereas under benignly perceived conditions the gains are retained to facilitate ontogenetic development. Ignorance may support instability by lacking the tools to reach contextual relevance, whereas knowledge may resolve the chaotic state by finding meaning through discovery. One could extrapolate that in the process of knowing, chaos may be our teacher and contextual relevance our reward.

If empathy can be conceived as a process that permits a temporary "jumping" out of self to affectively identify with non-self benignly, then compassion may be the emotion that resonates self with non-self to retain the expansions of external horizons. While Western psychology has concentrated on understanding "mental" and "emotional" pathological processes, we have much to learn about our most evolved biocognitions. Tibetan Buddhist psychology, for example, sees compassion as a powerful vehicle in the acquisition of knowledge (Dalai Lama, 2000; Rinbochay, 1980; Wallace, 1993).

There may be an evolutionary purpose for complex emotions such as empathy and compassion when one considers that subjects who simply observe the expression of emotions (e.g., watching a video of Mother Teresa tending to her patients) show increased levels of immunoglobulin type A

antibodies (IgA) [McClelland and Kirshnit, 1988].[10] It is interesting to note that although IgA levels increase when subjects are exposed to acts of compassion, levels drop after less than an hour in subjects with a cynical mindset, whereas subjects who hold a more optimistic view of the world maintain gains significantly longer (McClelland, 1989). IgA decreases associated with cynical interpretations of compassionate acts may exemplify temporary expansions of external horizons due to unresolved aversive bioethical codes. Biocultural interpretations may also affect contextual relevance at a cytocultural level — defined as the idiosyncratic history shared by a group of cells (Martinez and Santiago, 2001). It appears that cells may seek contextual relevance based on intercellular history. For example, Solomon, Kemeny, and Temoshok (1991) found that simpler but phylogenetically older immune cells such as natural killer cells (NK) respond to global social behavior (assertiveness) whereas more complex but phylogenetically younger immune cells such as T cells (CD4 and CD8) respond to more specific circumstances (reduced anxiety about illness). Phylogenetically older immune cells may have developed greater diversity due to a longer history of contextual challenges (George F. Solomon, personal communication, October, 28, 2000).

Varela and Frenk (1987) cogently argue that traditional biology has conceptualized organic form by how the scalpel separates the organs rather than by understanding that the organism is a continuum of cells and connective tissue, the extra cellular matrix (Maturana and Varela, 1980). Similarly, rather than accepting Pinker's (1997) clever but erroneous analogy of the brain as a "Swiss army knife," the process of knowing would be more accurately reflected in the paradoxical dialogues of Zen *mondos*.[11]

Conclusions

Biocognitive theory offers an alternative to the attribution of cause perpetuated by the life sciences. Historically, biology has borrowed the epistemology of physics to understand life, whereas cognitive science formulated ontology from a convergence of biology, physics, and philosophy to provide models of self that range from a passive acceptance of an outside world to the active creation of an inner. While Newtonian physics served us well in the physical sciences, mechanistic extrapolations to the life sciences precluded the embracement of more inclusive concepts offered by complexity and quantum theories. As long

[10]IgA's are antibodies, found in the saliva and other mucous membranes, which fight upper respiratory viruses.

[11]*Mondos* are dialogues with non-linear solutions that lead to deeper levels of meaning. Zen masters use them to teach their students paradoxical answers that transcend the linearity of language.

as the biological and cognitive sciences remain married to Newtonian physics and Cartesian dualism, mind will be relegated to an epiphenomenon of biology and mental processes and body functions will remain divided.

Rather that choosing between upward or downward causality, biocognitive theory offers contextual coemergence where the simultaneous resonance of contexts is the genesis of cause. In this model cognition, biology, and historical cultures are viewed as biocognitions within a field that possesses both linear and non-linear processes. Due to the simultaneous and reciprocal nature of communication, *biology creates thought and thought creates biology*. Just as mind and body cannot be divided, a separation of mind and world would create an artificial split between observer and observation that assumes we can step out of the world we are attempting to observe.

Bioinformation is archived as non-linear procedural traces contained in fractals of cognitive, biological, and cultural parameters and it is retrieved as precontextual biocognitions that coemerge to meaning through contextual relevance in linear space. A belief is defined as a commitment to how biocognition is contextualized. Contexts have internal horizons that maintain the internal coherence of an event or an organism as well as external horizons that define contextual relevance. Research in psychoneuroimmunology, medical anthropology, and cross-cultural medicine may converge to explore how the observer, the observing, and the observation coemerge in the process of knowing. While psychoneuroimmunology research has established a bi-directional pathway between cognition and biology, most studies exclude the influence of historical culture. Similarly, medical anthropology does not address the interaction of biology and cognition. Although scientific inquiry requires specialization, cohesive models are better suited to the life sciences. The biocognitive model may be an alternative to theories of knowledge that reduce ontology to DNA and epistemology to chance.

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