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Article

Bioentropy, Aesthetics and Meta-dualism: The Transdisciplinary Ecology of Gregory Bateson

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Abstract: In this paper I am going to be dealing with Gregory Bateson, a theorist who is one of the founders of cybernetics, an acknowledged precursor of Biosemiotics, and in all respects highly transdisciplinary. Until his entry into cybernetics Bateson was an anthropologist and like anthropologists of his day, accepted a semantic approach to meaning through the classic work of Ogden and Richards and their thought-word-meaning triangle. Ogden and Richards developed their semantic triangle from Peirce, but effectively turned the Peircian semiotic triad into a pentad of addressors and addressees, to which Bateson added context and reflexivity through feedback loops. The emergence of cybernetics and information theory in the 1940s increased the salience of the notion of feedback yet, he argued, information theory had truncated the notion of meaning. Bateson's discussion of the logical categories of learning and communication distinguished the difference between and 'sign' and 'signal'. Cybernetic signaling was a form of zero-learning; living systems were interpretative and engaged in several logical types of learning. Twenty years later he took up similar sorts of issues with regard to the new science of ecology which had framed systemic 'entropy' solely in thermodynamic terms and ignored communication and learning in living systems. His concept of Bioentropy is presented in section two of this paper as is its association with redundancy. Bioentropy, in turn, led to his offering an entirely new definition of information: "the difference that makes a difference." The definition could apply to both human and non-human communication patterns, since some forms of animal communication could not undertake logical typing. Finally, he believed that his own systemic approach was insufficient for meta-dualism. He promoted the idea of an ecological aesthetics which needed to be sufficiently objective to deal with the many disruptions in its own recursive relations, yet subjective and self-reflexive in the manner of a creative epistemology. 'Rigor' and

‘imagination’ became Bateson’s meta-logical types and aesthetics his meta-dualism. He drew his inspiration from the aesthetics of R.G. Collingwood. By mediating scientific rigor with Collingwood’s ‘imaginary’ Bateson brought about his own conception of mediated ‘thirdness’—different from C.S. Peirce—but one which brought cultural ‘mind’ more closely into association with ‘the mind of nature’.

Keywords: bioentropy; difference that makes a difference; learning; logical categories; recursion; Embodiment; Warren McCulloch; ecological flexibility; the imaginary; aesthetics; R.G. Collingwood

1. Cybernetics

1.1. Cybernetics and Norbert Wiener

Perhaps the scientific idea of Gregory Bateson that has traveled farthest is his expression that information is “the difference that makes a difference,” His formulation of information was devised quite late in his career, 25 years after the Macy cybernetics conferences, of which he was a founding member and five years after his career as a researcher at the Veteran’s Administration Hospital in Palo Alto, California, had come to an end. If one turns to Steven J. Heims’ seminal account of the Cybernetics Group based on records of their meetings during the 1940s and 1950s, it is evident that information theory was (and to some extent still is) dominated by the Shannon-Weaver theorems of the rate of the transmission of messages in a channel and the capacity of a channel to overcome noise and thus transmit information [1]. Norbert Wiener added that information was a constraint on the production of entropy in local systems, a sort of ‘negentropy’ or local island in a sea of entropy.

The process by which living beings resist the general stream of corruption and decay, says Wiener, is through homeostasis in its circular feedback. As Wiener defined the relationship between thermodynamics and ordering processes, information can bring about order in situations in which information is in a feedback circuit with its source. Information is in this sense a type of ‘conservation of time’. In the long run this ‘conservation of time’ does not contradict the Second Law of Thermodynamics, but could account for biological order on eEarth as, as a sort of ‘time binding,’ a localized reversal of the arrow of time. It also accounted for how certain organisms, including human beings are often able to increase their level of organization, creating order from chaos in the general stream of increasing entropy, and de-differentiation. Wiener acknowledged that his notion tying information to negentropy was a metaphor, rather than a validated hypothesis, but Bateson accepted that it was at metaphor that could be worked upon [2].

Nevertheless, the major unresolved issue of the cybernetics conferences was pointed out by Heinz von Foerster, for a long time secretary of the cybernetics group. He noted that while Shannon and Wiener concepts had become accepted in communications engineering as ‘information’ and that the cybernetics group used this conception of information in discussions, the terminology was a misrepresentation of the common sense use of the same term. Moreover, it did not apply to the human situation of messaging at all [3]. The reason was evident: neither the Shannon-Weaver nor Wiener

definitions included any reference to meaning in their respective elaborations of information and negentropy.

Bateson's reformulations were to be hard won from these terminological abstractions of the information engineers and physical scientists and for the fact that they felt little desire to match the technical sense of the term to its common sense usage. Norbert Wiener's opinion was that neither cybernetics nor information theory had much relevance for information as meaning as commonly used in the social sciences. Feedback in a mechanistic sense, implied loops in a cybernetic circuit which anticipate system output by feeding back information to input in order to adjust to ongoing variance or oscillation to an anticipated end, via a reference point inserted into the circuits of the system—so correcting deviance from the reference point. All this, the' thermostat model' of cybernetics, was very evident to Bateson. Yet he was more interested in the fact that that the looping events, and their recursions also could be seen in an alternate manner.

Significant events in cybernetics were 'events with constraint' which arise in temporal sequences within reticulate and near-circular processes of information flow. Thus the correction of error through feedback adjustment could be re-interpreted—not simply as homeostasis but as a form of 'learning'. So interpreted, the repetitions and oscillations observed in energy flow could also be said to express information qua information in the non-technical sense of 'meaningful news.' If so, it proposed a completely new understanding of purpose, and of 'teleology' that old devil of philosophical enquiry in the western world, with purpose and teleology being seen as embodied in the anticipation of events [4].

Despite his continuing frustration with the 'mechy-machs', as he sometimes called the communications engineers who made up the bulk of the membership of societies for cybernetics, Bateson continued to transform engineering concepts, pointing out inconsistencies in the narrowness of their arguments. Bateson knew he had to extricate cybernetics from its impoverished conception of meaning if its otherwise radical presentation of non-linearity was to lead to a broader understanding of recursive cause-and-effect. For example, the communication engineers in cybernetics continued to hold to the positivist view that the efficiencies of cybernetic circuits increased in proportion to the increased rate by which circuit design was able to eliminate noise. The communication engineers also held that homeostasis was effective in relation to the means by which it was able to damp down oscillation in the wider system.

Bateson believed that while 'noise eating' had its place, noise eating existed along with' noise sensitivity' and 'noise generation'. Thus increased 'time binding', or conservation of time, brought with it the counter-intuitive idea that an increase in differentiation can bring increase in order. But often increased differentiation, or variety, when it first appears, has similarities to, or cannot clearly be distinguished from 'noise' [5]. The latter is particularly interesting since, in the biological world, playfulness creates new adaptations from noise responses—a selection process of response to response. In his reinterpretation of cybernetics, he envisaged noise as playful and creative and which could become looped back into a system of communication as part of the creation of new patterns. His revisions with regard to noise are crucial adjustment, for one of the heaviest criticisms that assailed Wiener's conception of homeostasis was that the latter had not allowed for the creation of novelty, and thus had predicated cybernetics too heavily around concepts of control.

As we shall see, Bateson eventually abandoned Wiener's metaphor 'negentropy' as 'order from chaos', and introduced his own concept of 'bioentropy'—pattern from noise, the 'noise' of

differentiation. Bateson's final reformulation of information as "a difference that made a difference" explicitly defined information as meaningful to a somebody or some organism that could perceive difference and interpret its perceptual significance. With this inclusion of meaning or semiotic looping within cybernetics that he believed made it possible to transform technical cybernetics into the fundament of a new epistemology.

1.2. Error and the Setting of Feedback: Ross Ashby

Another person deeply influential in cybernetics was Ross Ashby. Ashby, it will be recalled, introduced the 'Law of Requisite Variety', and the proposition that only variety can control an increase in variety. Ashby extended prevailing notions of feedback in cybernetic systems into a general model of adaptation and change for any behavioural system. Ashby showed how processes of learning were correlated with biological adaptation: correlative matching of an organism with its environment generates processes that change the behaviour of an organism from a less to a more survival promoting form. He demonstrated from these principles how the interaction of organism and environment was applicable to the much broader field of evolution. Ashby noted that to be stable, biological systems must be 'loosely-joined' to their environment, with loose links both to local environments and to the system as a whole. If organism and environment were 'fully joined' with rich connectivity, the set of overall constraints with any perturbation would be so great that even relatively minor changes in the environment would kill the organism [6]. Ashby illustrated these principles of adaptation by means of an electro-mechanical model that he built which he called a homeostat, and through this demonstrated how change in stable systems was accommodated through step mechanisms. The homeostat changed values—took a step—only when the oscillation of system plus environment passed definite thresholds restraining the systems' critical states.

Bateson understood the importance of Ashby's demonstration, particularly his relation of step mechanisms to the processes of learning, and the processes of learning to the restraint of variety. This linked to Bateson's own earlier work on cultural aspects of learning that he had undertaken together with Margaret Mead [7]. Yet, on closer analysis he began to develop considerable doubts about the assumptions employed in Ashby's homeostat. One of these doubts concerned the same issue of noise noted above. In biological systems, noise was an enormous flexibility, a vital source for future adaptations and if biological adaptation did not include the possibilities for a system or subsystems to recycle errors, and in the process create new patterns from noisy sources, a vast potential for biological change was lost. Ashby's homeostat did not permit the recycling of error, but treated all error as an oscillation which the homeostat would constrain throughout the whole circuit.

Bateson then began to experiment with one of Ashby's homeostats and research its capabilities. He noted that homeostat-type modeling could not represent interactive communication exchange. Organism and environment were supposed to be interactive and interrelated as part to whole. In the homeostat this was achieved through having one system's input coupled to another system's output and vice versa and this accounted for aspects of mutuality in communication, and how each respond to perturbations or change in variety. But Bateson believed that the homeostat could not account for one vital aspect, namely the 'boundary conditions' by which an organism was coupled with its environment. Bateson held that any learning situation information of perturbation and change must

also include news about the difference of the boundaries between living organisms and environment. Without any feedback of the setting or feedback, the relation between information in the system and the meaning of the setting of relations in the system will remain confused. Or to put his point in simpler language, without a clearly defined context of relations, the import of information about organism-environment relations—the meaning of content—will be obscure. The homeostat did not provide this information, which was essential to any relationship between part and whole [8].

In fact, the more he looked into Ashby's electro-mechanical device, the more he came to realize that while Ashby's assumptions of control and entirely appropriate to functional interrelations in an energy-driven system, it lacked sufficient attention to interrelations typical of a communicative setting, where 'functional interrelations' were dependent on the sensing of differences in relations between one another. Homeostats, for example, could not model any situation in which the changing state of 'pupil' had any function in the overall 'teacher-pupil' system of relations. Nor could it model affect in those relations. While Bateson was prepared to excuse the latter, he believed that despite Ashby's claim to the contrary, the homeostat reduced system stabilities to a singly determined oscillation, the reduction of noise. In this respect the homeostat resembled a clockwork machine rather than a living organism [9].

1.3. The Logical Categories of Learning and Communication

The weaknesses he saw in Ashby's account led him to write one of his most influential papers, 'The Logical Categories of Learning and Communication' which began by distinguishing cybernetic restraints and corrections obtained by through human learning from that of cybernetic robots. As was a common format in many of Bateson's papers, he used a model with a series of levels to distinguish one set of characteristics from another, and in so far as he was able to address the digital rather than analogic coding in communication, he referred to these levels as 'logical types'. The full version of this paper was only published in 1964, and corrected in 1971, but prior publications, expressive of the same themes, stretch back into the 1940s. The 'Logical Categories of Learning and Communication' is, in effect, a compressed version of his whole approach to both communication and learning and their interrelationship; in the process it presents his central arguments on signs and signification [10]. Bateson begins with a discussion of 'zero learning' as an example of a set of activities that is sometimes referred to as 'learning' but in his estimation does not constitute 'learning' at all. One of the simplest examples of 'zero learning' is the case of electronic circuits, in which a correction to a response could be hard-wired into the circuit. It is a zero form of learning because the circuit structure is not itself subject to change when passages of impulses, sensory input enter within the circuit. It is an example of a simple receipt of corrective information from an external event in such a way that a similar event at a later time will convey the same information [11].

There are more complex examples which are of the same type in human and animal communication, for example, where the pattern of response is minimally determined by experience and maximally determined by genetic factors; or in cases of habituation, where the animal has ceased to give an overt response to what was a formerly disturbing stimulus. One of the most complex uses of 'zero learning' was that undertaken by John von Neumann's models in his elaborations of game theory. Game theory permits discovery of error, and correction to error, but does not permit the individual who discovers his own error to contribute anything to his or her future skill and stances.

When the same problem returns at a later time, the player will correctly go through the same computations as the time before and reach the same decision. Game theory, therefore, is a theory of correcting errors without undertaking change.

Bateson's definition of learning is that the word "undoubtably denotes *change* of some order, but to say what *kind* of change is a delicate matter... change denotes process. But processes are themselves subject to 'change'." If all learning has within it an elements of change, then Learning I contains all those items which are most commonly called 'learning' in the standard psychological laboratory. Learning I would include the phenomenon of rote learning in which any of the items learned in rote manner which affect the behaviour of the organism, for example, instrumental rewards of food, then becomes its own stimulus for another item of behaviour when the instrumental reward of food occur again. In Learning 1 cases, the organism at Time 2 will give a different response from that which it made at Time 1. This could include loss of habituation. The change that occurs with Learning 1 is related to an acquisition of the *context* in which events occur, or, to use the notion of percept, a percept of how events are punctuated. Context of a stimulus is a meta-message which classifies the elementary signal, and organisms respond to classification that they themselves have made of the elementary signal, either internal signal, or external signal, or combination of both. In many instances there may be no specific signal or label which will classify and differentiate contexts and organisms will have to get information from actual congeries of events that make up the context in each case—and compare. At the same time, there occur signals which classify contexts and these occur "certainly in human life and probably in that of many other organisms" [12]. Such signals that serve as classifiers could be called "context markers". It is very much easier to speak of 'context markers' and to relate these to a logic of classification, logical types, wherever language enters into communication. But wherever purely analogue, or purely iconic, communication occurs there is no possibility for distinguishing context markers. One cannot compare on the basis that one context marker is 'not' the other context marker, because there is no digital signal for 'not'.

"There is, in fact almost no formal theory dealing with analogue communication, and, in particular, no equivalent of Information Theory or Logical Type Theory. This gap is inconvenient when we leave the rarified world of logic and mathematics and come to face to face with the phenomena of natural history... In the natural world communication is rarely either purely digital or purely analogic... At the digital end of this scale all the theorems of information theory have their full force, but at the ostensive an analogic end they are meaningless... (Nevertheless) the internal mechanism of (higher mammals) has become digitalized at least at the neuronal level" [13].

Bateson proceeds to Learning II after identifying the sort of change occurring in Learning I. Learning II constitutes a change in the process of Learning I, a corrective change in the set of alternatives from which choice is made, or a change in how the sequence of experience is punctuated. Another way of looking at Learning II is describing it as 'learning to learn' or learning about different contexts in which learning takes place and hence—if one would speak of learning as a form of perception of events—undertaking an change in prior learning of the 'punctuating' of how events occur. Learning I includes the punctuation of events and context marking in human interaction. These lend their shape to processes of Learning II, and create contingency patterns for Learning II, which is a change of response to specific patterns of response (already classified as contexts of response), and this change in specific patterns of response is itself induced through change. The requirement for

Learning II, that is to say, the second order percepts of 'learning to learn' is quite common and necessary in human life. Learning II is learning about the characteristics of contradiction and the ways in which the human individual can cope and achieve economies in the stream of contradiction which the individual will have to face in life. Failure to deal with such contradictions at level II gives rise to "double binds". In the process of learning to learn, a person will learn a set of self-validating premises. Behaviour controlled by Learning II will be of such a kind as to mold the total context to the expected punctuation. It is a meta-message of a meta-message, and this self-validating characteristic of the context of Learning II has the effect that such learning is almost ineradicable [14]. Bateson is of the opinion that Freud was correct in suggesting that Learning II acquired in infancy is likely to persist in life and is unconscious. Bateson adds that the unconscious here not only includes that which Freud termed 'repressed material' but most of the non-conscious processes and habits of gestalt perception.

Learning III is a change in the process of Learning II, a corrective change in the whole system in which an individual chooses sets and changes alternatives from his or her set of self-validating premises. Learning III involves change in the premises of what is called the 'character' of the individual and the definition of 'self' in undertaking any form of behavioural-communicative interaction. Learning III must lead to greater flexibility in the premises acquired by the processes of Learning II and a freedom from their bondage. To the degree that a person is able to perceive and act in terms of the contexts of contexts, "the concept of self will no longer function as a nodal argument in the punctuation of experience." In other words, selfhood is a product or aggregate of Learning II, but with Learning III 'I' am no longer the aggregate of those characteristics which I call my character and 'the self' takes on a sort of irrelevance. Not only is it difficult or rare for human beings to undergo such changes, but Bateson notes, that it is also difficult for scientists to imagine or describe this process of change in learning about Learning II, particularly since all error, and corrections and self-validation of corrections above zero learning are shown to occur in circular, and therefore non-linear patterns of anticipation and change in anticipations.

1.4. Embodiment

We may leave Bateson's discussion of the hierarchical form of logical categories and of Learning IV that follow in his article on learning and communication in order to take up a theme within his article which requires its own investigation. This is Bateson's notions of embodiment, especially embodiment of 'selfhood'. Unlike almost all the other empirical theorists of cybernetics, and nearly all phenomenologists, Bateson rejected the concept of meaning as arising simply from a physical trace in the body, a sensation, an external neural signal from environment or, in the case of phenomenologists, and external signal combined with an internal signal from memory. Bateson proposed that, in addition, all communicative embodiment was relational, that the relational aspects of receipt of information were an important part of creation of contexts of communication. He went along with the pragmatists to the extent that he believed meaning to be prospective, so that what counts are the outcomes of communication and the way in which communicative interplay expresses an idea about connections in relationship that are yet to be instituted. Again, like most pragmatists, his epistemological arenas for the working out of such ideas about relations was that of the ordinary, everyday life in the everyday world in which the observer's analysis of meaning focuses on particular contexts.

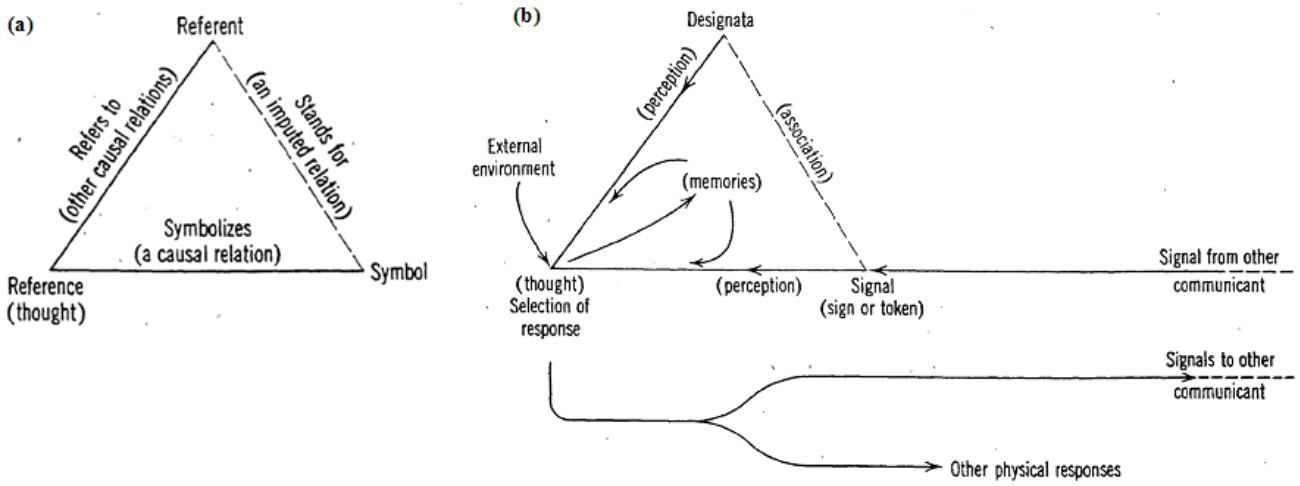
However, most pragmatists coordinated epistemological space with action and proceeded to analyze 'normal actions' as defined by the ordinary community, which, in turn imputed cultural perspectives. Bateson was exceptional in that he focused on pathologies to which particular contexts of communication may give rise, on the grounds that analyzing normal flows of communicative relationships in any arena was almost impossible, since it was impossible for any observer to define the whole range of normal activity from which 'normal flows' might arise, even within a single culture. Rather he concentrated on mis-perception of communicative pattern. Mis-perception is, of course congruent with action or non-action as the case may be, and in his more specialized papers he unites these with pathologies of 'purpose', context- errors, and mistaken conceptions of part-whole relations. His 'Cybernetics of Self', a paper about the success of Alcoholics Anonymous in treating alcoholism, is a classic example of his approach [15]. Nevertheless, patterns of perception established and maintained between members of a communicative system enter decisively into his discussion of Learning II and Learning III.

His strategy also illustrates Bateson's way of avoiding some of the pitfalls of pragmatism. Pragmatism examined communicative relations as if the observer was a scientist looking for empirical invariants and this approach seemed incompatible with all the variety in conversational metaphor. His recognition of rigidities in the pragmatic perspective arose out of his earlier career as an anthropologist, when he undertook two major fieldwork studies. The first of these was on the Sepik River of New Guinea, and the second of a village in the upper highlands of Bali. In the New Guinea study during the early 1930s he took up an issue which was of general concern to all anthropologists of that time, namely what patterns of relationship within village circumstances led to village stability and continuity, or what led to social friction and dispersal. His fieldwork was unusual in that he examined the issue with an eye to the dynamics of social situations as they evolved, whereas most anthropologists gave a static account of village organization, a synchronic description as it was termed, as if all village organization was composed of habituated activity, a system of rules that existed unchanged over time. Break-up and dispersal of village organization through the dynamics of social interaction was rarely recorded. Bateson not only examined the processual aspects of verbal conflict and of reconciliation in his New Guinea village, but the totemic logic or *eidos*, as he called it, behind the process. His examination of the means through which villagers pre-empted disputes leading to an out of control situation initiated a preliminary understanding of non-linearity in events and how positive feedback can lead to vicious circles. At that time, he had no knowledge of how a different type of feedback might lead to virtuous circles [16].

The British school of social anthropology in which Bateson was immersed before marrying Mead and moving to the United States, dealt a great deal with issues of symbolism in relation to everyday life and the British school regularly cited the 1923 work of Ogden and Richards [18]. British Social Anthropology found the Ogden and Richards view very congenial, especially since that volume contained a special section authored by Bronislaw Malinowski, one of the founders of modern social anthropology [17]. Ogden and Richards stressed the essential triadic relations of meaning, as depicted in their thought-word-thing triangle (see Diagram). The triangle depicted thought—or a person having thoughts—as being bound up together with a symbol and a referent. One side of this triangle, or triad, correlated symbols to thought in a causal manner; a second side correlated thought to reference, a correspondence that also had causal relations; whilst the third side of the triadic

relationship—correlated symbol to referent—a correspondence which imputed non-causal relations. In the Ogden and Richards view, meaning did not simply arise from words in speech. They took the view that words in speech, *i.e.*, content spoken did not organize things, rather speech organized thought in people and people organized things. Moreover, since symbols bore a causal relation to organized thoughts [18] symbols were primary components of any cultural response in any society.

Figure 1. Words and meaning. Signal-thought-designata relations. (a) The thought-word-thing triangle, after C.K. Ogden and I.A. Richards, *Meaning of Meaning* [17]; (b) "Meaning of words" A functional flow diagram [18].



Nevertheless, a significant number of features have to be added to this depiction of semantics and meaning if Ogden and Richards thought-word thing triangle is to be made amenable to communication that goes on in ordinary or 'normal' conversational dialogue. Considered on its own, the Ogden and Richards thought-word-thing triangle appears to be the response of a single individual to a receipt of information. It is not sufficient to reflect a variety of cultural performances on the part of many members in a culture drawn together through interpersonal communication. These significant additions are presented in the bottom part of the Diagram as a processual flow. This diagram of 'the meaning of words' was drawn by Cherry in his classic work *On Human Communication* [18]. They include signs/signals issuing from and to both utterer and listeners; they include a change in terminology to reflect perception of a sign/signal from another communicant; the perception in the selection of a response to that sign/signal and the designata (object); and other physical responses to and from the external environment. A most important addition includes a "memory loop" indicating the way in which a communicative response draws upon the context of prior response. Now, the Diagram becomes sufficiently flexible to begin to portray the various conditions of embodiment of signs and their meaning that Bateson requires when speaking of responses in Learning I and from Learning I to Learning II to Learning III.

1.5. Warren McCulloch

McCulloch was another prominent member of the foundational group in cybernetics. He had produced evidence to show that there were several types of circular paths or dromes that travel through

nervous nets and that long term and short term memory is associated with these characteristic circular paths [19]. He argued that the dominant form of communication in nervous nets, its topological form, does not emanate from a single, controlling top-down hierarchical order in our brain. There was not a grand homeobox in the nervous system which replicated command and control found in political, bureaucratic, military and entrepreneurial organizations. Instead, meaning emerges in a completely different manner, largely through our understanding of oscillating contexts both 'inside' and 'outside' in what was generally regarded at that time as both 'brain' and 'mind'. McCulloch suggests that the formal components from which meaning is drawn are heterarchical, *i.e.*, drawn from several domains within a plural chain of selections that render the meaningful in a context.

Bateson added to this that heterarchical patterning itself is an embodiment of our ways of thinking and acting in an interactive setting. From this revision in the topology of how a message is believed to be 'carried' in a circuit, Bateson is able to elaborate upon patterns of how what we learn is coupled to our assumptions of how we learn, and, in turn, drawn recursively into our own epistemology. Second order embodiment of communication leads on to third order embodiment with each level of context expressing a pattern of heterarchical preferences which in turn require a meta-context. We will return to this point later in discussion Bateson's approach to aesthetics.

Bateson believed his schema was a great an improvement over the notions of traces or other theories of physical embodiment which had previously dominated western thinking. In 1957 he wrote that if the holism of the eighteenth century had been the 'great chain of being', a hierarchy covering all ideas to the point of obsessive rationalism, and that hierarchy of being in the nineteenth century made rationalism coincident with forms of materialism, then the holism of the late twentieth century lay in neither of these forms but in cybernetics. From cybernetics would emerge a new system of systemic thought characterized by a heterarchy of levels of communication. Unfortunately, by the time of Bateson's death, his own elaborations for a heterarchical interpretation of meaning, based on McCulloch's ideas, had yet to appear. Others too had failed to follow-up this concept either logically, or mathematically. A recent paper suggested that McCulloch's idea of heterarchy had lay dormant for 60 years because nearly all mathematics and nearly all logics were mono-causal in their assumptions about selection while heterarchy required adoption of pluri-causal selections and change in pluri-causal selective processes; and both elements of pluri-causality were well beyond standard mathematical and logical approaches, even today [20].

Another prominent theme of Warren McCulloch was his elaboration of the concept of redundancy [21]. The design of the nervous system clearly demonstrates that enormous corruption of information will occur in any sort of communication via the senses. To be specific, the eye relays to the brain about one-hundredth of its information, as a result of a constant checking and rechecking of the accuracy of the information which it receives. While overall information is decimated, usable information is enhanced. As a result, the chance that the usable information which the brain receives is in error is fantastically small, a billionth of a billionth of a tenth of one per cent. Usable information is a corollary of the primacy of redundancy in neural organization. Redundancy ensures that any element in the neural network is repeated, and repeated, and repeated. Instead of being a supernumerary feature of the neural network, the very primacy of its redundancy ensures an extremely high chance that whatever information the nervous system receives is coincident with something in the world, or, in the term of materialist philosophy, 'reality'.

The chief reason for the enormous reduction from afferent signals to efferent signals is the requirement of coincidence along the way. Every such requirement of coincidence increases the assurance which can be placed in any subsequent signal, for that signal must then be due to coincidence in the world impinging on our receptors and we achieve an immense certainty that what we observe is due to something in the world [22]. If massive redundancy and the constant washing out of random variations through coincidence detection precludes the usual notions of determinate interconnection, then, argues McCulloch, whatever the mind may be, it is not an embodiment of the logical principles of predictability on which Western science had built so much. Instead, the nervous system was fundamentally relational, deriving its order through congruence of patterned redundancy.

Bateson believed that as a result of McCulloch's work, most behavioural principles based on the notion of continuous implication would have to be revised. So, too, would that part of psychoanalysis which assumed that consciousness provided a continuity between the representation of the 'real world' outside individuals' bodies and the 'world' inside their heads. McCulloch and others had struck at the central dogma of Western science. By showing that the brain is not a separate centre of the body, but embraces ideas, feelings, memory, and aesthetics, he had totally reformulated body-mind dualism:

'A queer business', Bateson wrote in one of his early letters to McCulloch, 'how the world which previously contained elements of coherence becomes again a jigsaw puzzle when a new theoretical approach is devised, and then one has to go around picking up the pieces all over again' [23].

To Bateson the importance of redundancy did not stop with the revelations pertaining to physical architecture of the nervous system. He also pursued the concept of redundancy in relation to 'coding' and to 'meaning'. When engineers and mathematicians look at the internal structure of message material, the message material is said to contain redundancy if, when the sequence is received with some items missing, the receiver is able to guess at the missing items with better than random success. The term 'redundancy' so used in this way becomes a synonym for 'patterning' and this patterning of message material helps the receiver to differentiate between signal and noise. In addition, he would argue that the concept 'redundancy' enters into context and is at least partial synonym of 'meaning' [24]:

"As I see it, if the receiver can guess at missing parts of the message, then those parts which are received must, in fact, carry a meaning which refers to the missing parts and is information about those parts... (The) outer world is similarly characterized by redundancy *i.e.*, that when an observer perceives only certain parts of a sequence or a configuration of phenomena, he is in many cases able to guess, with better than random success, at parts which he cannot immediately perceive."

So it is a principal goal of the scientist to elucidate these redundancies or patterning of the phenomenal world. Within the restricted universe of the message sequence or content of the message, redundancy is not, of course, synonymous with 'meaning'. It is however in the wider universe that includes both message and external referent. Here 'redundancy' and 'meaning' become synonymous, that is, whenever both words are applied to the same universe of discourse, in the case of human communication, or whenever that larger universe of which these two sub-universes are parts, *i.e.*, the system: message plus external phenomena—as in the case of animal communication. Occasionally actual pieces of the external environment—scraps of potential nest building material, 'trophies,' and the like—are used for animal communication and contribute redundancy, but generally the message

and the response is that of *message plus the relationship between the organisms*, rather than message plus external environment.

Since the physical environment contains internal patterning or redundancy *i.e.*, the perception of certain events or object makes other events or object predictable for the animals. In addition sound or other signals from one animal may contribute redundancy to the system; *i.e.*, the signal may be 'about' the environment. Then communicative interaction may contribute redundancy to the universe; *A's signals plus B's signals*, that is, the signals may be *about* the interaction of which they are component parts. In addition, the sequence of signals will certainly contain redundancy—one signal from an animal making another signal from the same animal more predictable. Finally, since animals are capable of *learning*, learning about repetition of sequences may lead to their becoming effective as redundant patterns.

The external universe is also redundant in the sense that it is replete with part-for-whole messages. In fact the very term 'redundancy' is a general rubric for 'part-for-whole' phenomena, the most easily recognized of which are the different sorts of relationship between part-and-whole that occur in the case of iconic coding among animals. In animals, the part may be real components of an existing sequence, or whole, such as the bared fang of a dog, may be part of a real attack. The whole category of messages which ethologists call "intention movements" is also part-for whole coding, composed of postures and muscular contractions which, if completed, would be actions of aggression, sex, retreat, eating, nest building *etc*. The part may have only a conditional relationship to its whole, in which case the bared fang may be the beginning of a threatened attack, *i.e.*, *may be completed* unless certain conditions are met. Alternatively, the part may be completely split from the whole which is its referent, as in the case where the bared fang at the given instant may mention an attack which, if and when it occurs, will include a new bearing of the fangs. Here, the 'part' has not become a true iconic signal. Finally, the part may take on a special ritual or metaphoric meanings in a context where the original whole to which it once referred is no longer relevant. Thus the game of mutual mouthing between mother dog and puppy which once followed her weaning of the pup may become a ritual aggregation.

In the case of humans, redundancy in the relationships between persons is still preponderantly iconic. It is achieved by means of kinesics, paralinguistics, intention movements, actions, and the like. Some have proposed that these latter were evolutionary forebears of language, but far from being 'primitive' forms in humankind, they have become enormously enriched through human cultural performances. It appears that at least two steps were necessary to get from the animal iconic use of part-of-a-whole to patterns of iconicity in our own behaviour. There was both a change in coding of iconicity through the naming of entities is the external environment and a change in the centring of the subject-predicate frame. There can be no simple way for an animal to say "I will not bite you". Among animals the important message "I will not bite you" is generated as an *agreement* between two organisms following real or ritual combat. And again, many of the curious interactions of animals called "play" resemble (but are not) combat. They are cumbersome and awkward methods of achieving the negative through testing and reaffirming their mutual negative agreement. However their mutual negative agreement of 'Don't' is very different from the subject-predicate negation, 'Not' [25].

Redundancy as a way of thinking about communication, for it groups all methods of coding under the single rubric of part-for-whole. It is possible to find part-for-whole coding in a variety of codes besides those of iconicity. They include digital, analogic, ostensive and the causal correlative coding

of empirical testing of the Hume variety. The most unusual coding lies in evolutionary coding, says Bateson. The information which is accumulated in organisms by evolutionary process is not usually of any of the sorts listed above. It is rather *complementary* to those environmental phenomena to which the organisms must adjust. Thus the embryo shark does not have information about hydrodynamics but about how to grow a shape which will necessarily develop as a complement to the surrounding hydrodynamics.

2. Bioentropy

2.1. Bioentropy and Cybernetics

When Bateson decided to leave his Palo Alto colleagues and so leave active work in psychotherapy to take up research on cetaceans, it would seem as if he was moving into an entirely different field of scientific enquiry. Yet Bateson the psychotherapist was also a biologist, son of a noted father who was the English translator of Gregory Mendel, and noted protagonist of Charles Darwin. The Modern Synthesis in Biology came about to heal the split between the Darwinians and those supporting Mendel, and William Bateson was among the most prominent of the Mendelians. Much of Bateson's early work both in anthropology, and later on communication, and systemic psychotherapy was prompted by biological ideas, especially his father's belief in Mendelian discontinuities.

The term 'learning' along with 'ecology' and 'ecological complexity' appear in Bateson's thinking as early as 1943. In a memorandum of that time he wrote that learning "is a general mammalian phenomena". "Learning becomes a keystone of any theoretical approach to (human) social structure", since, "without learning humans were thrown into a hopeless determinism". Equally, the characteristics of animal learning had been scarcely studied in the wild. Where animal learning had been studied, these studies presupposed, in the manner of Charles Darwin, that adaptation was a continuous unbroken temporal phenomenon. The scientific emphasis always seemed to stress how limited was an animal's capacity to learn. Bateson did not believe either of these propositions. Instead all learning, both human and animal is an expression of a time series of semi-gestalts. Learning "is all a matter of events *i.e.*, discontinuous phenomena which crop up in some sort of order and sequence in a time matrix." [26]. Bateson is implying that if the event structure of learning is tied into adaptation, and his view of discontinuity in learning was correct, then, the whole issue of adaptation in the studies of evolution would have to be re-formulated as a learning process involving semi-gestalt plus time series delays.

He sends a letter to Evelyn Hutchinson, who today is regarded as one of the founders of the study of ecology in North America. A proposal from Hutchinson to the American Museum of Natural History at this time called for a Museum presentation on environmental issues. His memo is a critique of Hutchinson's proposal because, like most ecologists of his time, Hutchinson wanted to present environmental issues solely in terms of the distribution of physico-chemical factors in ecosystems, or what Hutchinson called 'the biotic factors in human autecology'. Bateson was critical of the fact that Hutchinson had left the whole topic of learning out of his presentation of environmental issues.

When he came back to the same subject in and around 1970, he observed that little had changed in ecological theory. There were indeed new books and papers calling themselves 'environmental' or 'ecological' to herald a whole new subject of enquiry, but study of the material forces of nature

dominated the study of ecosystems. The methodology of ecological studies still relied upon approaches drawn from physics and chemistry. It still paid little attention to animal learning, nor incorporated such study into an enquiry on evolution and ecosystem adaptation.

As he had said in his 1943 memo, ecology should be an overarching discipline that would deal with adaptation among animals and learning among human beings based on an entirely different set of 'biotic factors' than those of energy and biomass. It had become too easy for modern science to continue to treat the biosphere as it had treated any other 'mechanism' since the sixteenth century and to neglect the so-called 'mystery' of ecological unity. There should be general investigation of how parts fit into a holistic order, and vice versa, how holistic order is contained in the development of parts. Such an investigation would require an approach very different from a wholesale reduction of ecological order to physical events.

By 1970 many of his talks and essays had pointed out that living systems are non-linear systems, recursive in a way in which physical systems are not. In addition, investigators must recognize that any observer of biological systems is always engaged in *participant investigation,* in a manner that observers' of physical and material systems are not. The failure to recognize human participation within ecosystems, even though those systems had definite physical characteristics, was an error in perception which will always come around to stab the observer in the back.

2.2. Thermodynamics and Ecological Flexibility

When Bateson came to consider ecosystems, he believed that thermodynamic entropy had been too narrowly defined. He agreed, of course, that organic systems require a positive energy budget in order to survive, but believed that the subsequent expression of positive energy budgets in relation to the capacity for work did not sufficiently acknowledge the ordering component of information in ecosystems. In other words, Weiner and Shannon had defined information in order to meet the requirements of a physical research program started in engineering in the 1940s, with the goal of rationalizing the science of sending messages through communication channels. The information of a message was evaluated by the probability distribution of its elements. Thus they generated their idea that *information,* in a physical sense, is an inverse function of *physical disorder*. Since the disorder of a system is measured by its entropy (represented as a dimensionless quantity), the same concept was applied to all aspects of information theory. The information of a message was defined by the dimensionless negative entropy of the system, *i.e.*, by the negative of its probability distribution.

The problem, as Bateson realized, is that information obtained by Shannon and Weaver's formula does not depend on the sequence of the elements; while biological information is defined precisely by such sequences. In other words, physical information has nothing to do with *specificity*, while biological information has everything to do with it. The two concepts of information were worlds apart. Thus while ecologists like H.T. Odum continued to appraise living organization of ecosystems *solely* in terms of its physcial properties of biomass and energy and with conventional definitions of ecosystem = energy = capacity for work, Bateson proposed that the 'soft science' of biology had it right in when it noted that metabolism rates were different in kind from physical flux. Organisms had the ability to regulate their chemical activities or compensate for changes that result in an imbalance to its activities of reproduction, growth, and movement. Within a wide range of constraints, *i.e.*, within

their thresholds of tolerance of heat or cold, living molecules did not display a direct response to changed conditions of physical flux; and within these constraints, information is the equivalent of organization.

In more recent years there has been a considerable shift in attitude regarding what exactly it is that the probabilities of (*H subscript n*) that information measures "This change has been away from the idea that probabilities measure our ignorance about a deterministic situation, toward the notion that they reflect *an indeterminacy inherent in the process itself*" [27]. The general idea has gained ground in the last decade or so that if information has a relation with entropy it is because information refers to *system constraints*, and those constraints, in turn, impart order and pattern to a system as a whole, rather than being particular states of knowledge under uncertainty. A modified notion of information theory can still be retained to measure connectivity in a network of pathways in an ecosystem but only if an ecosystem is not treated as a deterministic system, nor in terms of mechanical dynamics.

The overall confusion about the place of information in ecosystems encouraged Bateson to use the term "Bioentropy" to distinguish variety in living organization with its organized response to communicative and metabolic flux. It is not a word that is readily found in the usual dictionaries. The use of this term inevitably created puzzled questions among the cohort of ecologists to whom he wrote letters about his ideas [28]. No wonder—Bateson was reconfiguring the notion of 'entropy' in biological order. Rather than a necessary characteristic of thermodynamic 'work', bioentropy bore relation to a variety of patterning about systemic information and/or indeterminancy in ecosystems His argument reversed the direction of change of entropy from 'rundown'—as a colloquial expression of entropy in a thermodynamic sense—to a condition where variety or differentiation 'runs up against' conditions where information can no longer create pattern. This reversal of direction of movement suggests that information is a complementarity to 'work'. It is perfectly correct given Wiener's original expression that information was some equivalent to 'negentropy' or reversal of a sea of flux moving towards homogeneity, through increasing local 'islands of order' in *i.e.*, information creates local patterning in an overall disorganized 'run down' of a thermodynamic state.

Bateson argued that as a condition of informational order, bioentropy could be examined as an analogue of flexibility. He referred to bioentropy as part of an "economics of flexibility" necessary for any organism subject to evolutionary change. From this he began to develop the notion of ecosystems as a contextual ordering of flexibility. The following passage suggests one of Bateson's formulations: [29]

"It is worth noting here that (biological) flexibility is to specialization as entropy is to negentropy. Flexibility may be defined as *uncommitted potentiality for change*. A telephone exchange exhibits maximum negentropy, maximum specialization, maximum information load, and maximum rigidity when so many of its circuits are in use that one more call would probably jam the system. It exhibits maximum entropy and maximum flexibility when none of its pathways are committed. (In this particular example, the state of non-use is not a committed state). It will be noted that the budget of flexibility is fractionating (not subtractive, as is a budget of money or energy)."

The analogue of an endpoint in informational entropy is therefore, not so much maximal homogeneity as maximal rigidity. In the world of living organisms, conditions of maximal flexibility are those conditions that approximate 'noise' (entropy) before their patterning of interactions takes place. Bioentropy focuses on the ability of organisms to create pattern from noise in a systemic

informational context. To maintain flexibility, either flexibility must be exercised—the 'flexibility' of biological order resting within its communicative structure—or the encroaching variables which serve to jam the overall system must be controlled. Bateson argues that success in survival lies in avoiding either of the maximal conditions.

His point is more readily grasped if we take information in an ecological setting to be 'variety', as Ross Ashby originally used the term. Continually changing natural environment yields 'variety' in which organisms develop through patterned response according to a budget of available energy. The pattern itself derives from information messages that trigger a response to available energy. The symptoms of this are visible to humans in the wide variation of living systems response to physical flux, and to their adaptations to change. For example, animal dormancy is widespread and so is dormancy in plants that grow in harsh environmental conditions. The desert landscape reveals plants that can lay dormant underground for many years, then with a touch of rain suddenly, emerge, flower, reproduce and lie dormant again all within a remarkably short period of time. This variety in the way that information triggers allocation of energy flux touches not only upon particular species, but is ecosystemic, that means the triggering affects composition and persistence of populations of plant and animal species in relation to each other throughout desert ecosystems.

Bateson also argues that formal patterns of mutual interaction will breakdown some time before the flow of material energy runs out and this is because the flow of systemic information through animal communicative interactions within an ecosystem may exhibit either runaway increase or runaway decrease in any ecosystem. An informational ecosystem is always multiplicative with respect to change and exhibits entirely different response rates to change than is expressed in the physical laws of thermodynamics. While changes in physico-chemical processes usually require a fairly massive shift in energy transfer to occur, information change may result from the slightest change in information patterns. Hence when it comes to ecological degradation the primary stresses will be through triggering differential responses within the formal properties of the organization of living systems. The systemic flow of mutual communicative interactions will breakdown some time before the flow of material energy runs out because and response among many species at the same time would be multiple and conflictual. Such a case of communicative degradation would created an "about to be jammed or seized up" condition in a network of circuits, much as human response in a panic jams up a telephone exchange (at least in Bateson's time when telephonic connection through land lines). In other words, it would create a situation approximating maximal rigidity.

The notion of bioentropy also refers to the fact that conditions of life require semantic capacity, an ability to perceive and to translate perception into meaning, even in quite minimal ways. All living forms in their mutual interactions exhibit expectancy, the most evident examples occurring in response to sexual reproduction, but all expectancies are subject to surprise, namely conditions of change. Changes of interaction occur in anticipation of, and in response to, increased ecosystem stress. As in all biological information and communication, change requires contextual interpretation for it to have any meaning. In a continually changing environment living organisms develop different patterns of response to information. Yet an appropriate adaptation at one time may well become disadvantageous at another. No wonder Bateson argued that the most appropriate definition of survival is survival of the most flexible: [30].

"The strategy for survival of a species or an ecological community can only be immediately governed by contingency but is continually being tested in terms of longer time spans, larger gestalten and unpredictable change which cannot be foreseen... the fight is not only to the strong and well adapted, it is also to the *flexible* (the ability of that organism which at this moment is prospering in a given environment) to survive under change and possibly adverse conditions. But we do not know what changes or what adverse conditions the organism should be prepared for."

2.3. Bioentropy and Natural Selection

By implication the notion of Bioentropy challenges the Darwinian notion of natural selection as a universal characteristic of the responses of individual creatures to the external stress of environment or competition from other creatures. Bateson believed that Darwinists had reduced the complex variety of activities involved in survival, reproduction, and species interactions to a uniform rule, that of 'natural selection', and that they turned this supposedly universal characteristic of response to stress into the status of a natural law. Natural selection had become a basic concept of modern biology, one which accounts not only for variety, but also for the emergence of every biological novelty, and for successful adaptation. A Darwinian might agree with Bateson that adaptation is also governed by contingencies such as the life cycle of a species, and that all species move toward a pattern of extinction, but in very different time spans. Yet they could never conceive, as Bateson did, of successful adaptation requiring a capacity for 'larger gestalten', for this would indicate the existence of reflexive awareness in a species in relation to its interactions with other plant and animal species. Survival profiles in Darwinian concepts all referred to material dispositions.

That natural selection occurs is beyond dispute so far as Bateson is concerned. Natural selection controls local populations of phenotypes and this local system of constraint registers in local composition of living systems. Moreover, under localized natural selection, some fitness function not only works on individuals but can determine what the next state of the system will be *i.e.*, there is some bottom-up causality. Yet, Bateson argued, natural selection is not a determining condition in all evolutionary circumstance, equivalent in scope to a physical law.

Bateson held to the convention that biological systems are ordered hierarchically, and since they are ordered in this manner, homeostatic fitness values are represented in a highly abstract manner in the upper levels of that hierarchy, while at lower levels the homeostasis fitness values are not isomorphic to the homeostatic repetitions at a higher level. In other words, a fitness function may be viewed as instantiating a homeostatic value ('habit' or set of values preserving survival), but even if the survival values are thus preserved, they are not explicitly coded in a fitness function in a way in which they are isomorphic at all levels of expression. The pattern of cybernation is never exactly the same at each level of the biological hierarchy.

Darwinists also treat natural selection with its catch phrase 'the survival of the fittest' as being a zero-sum game between individuals in a species in which 'selection' occurs through direct interaction, the maximal fitness of single individuals cumulatively producing a physical ability to survive the vagaries of nature in a species over time. Bateson, on the other hand, speaks as a developmental biologist, who, while acknowledging that the processes of molecular genetics produce a pattern of gene activity which applies to the special circumstances of the genomic level, nevertheless emphasizes

that genomic processes from thereon involve many other levels of organization. Thus, gene processes are carried forward to the organization of the phenotype. Here new developmental processes build new organism-level patterns and these then become the raw material for yet higher level processes acting at the next level. A 'level' might apply to activity in the embryonic stage inside an organism's body as with genetic variation expressed at the general level. But a level may also apply to phenotypic variation at the individual level, or demic variation only at the demic level. The convention is that each will reflect processes acting on preceding levels—but a species level is held also to act as >individual.

Developmentalist biologists, unlike molecular biologists, pay particular attention to these separable levels of complexity and seek to find schemes where different rules and concepts operate among these many levels. It was Bateson's particular contribution to recognize that within multi-level biological systems any interactive system with incipient hierarchy has contrasts between actual patterning and the processual operations—as well evident interdependence of pattern and process—and that these contrasts carry forward to the next level [31].

Bateson's not-so-hidden message is that the course of evolution is much more indeterminate because systemic informational effects do not necessarily match informational effects in any one particular level. The successful phenotype, that is, the one which survives, is a phenotype which exhibits an optimal range of characteristics at several levels, including, of course, that of communication with other members of the species, and inter-species communication. He believed Darwin and his followers had fragmented a vast ecological complex of events into activities of single living units and then, through their particular definition of survival, re-synthesized the complex of events into a single-unit activity—reproductive fitness. He believed that false Darwinian premises were largely responsible for the degradation of our planetary ecology [32].

"The impact of every simplified biological or social dogma upon our society (based on materialism) has contained the seeds of disaster, natural selection, economic determinism, territorial imperative, laissez faire, autocracy, democracy, individualism, operant conditioning, Lamarckian inheritance the racial and genetic determination of character, and so on—every major theme of the life sciences proposes a path towards nightmares... "

As discussed above, Bateson proposed that the concept of "fit" is a low-level analogue for "matching flexibility". Survival depends on those who best manage to retain flexible interactive strategies among the dilemmas that environment always poses. Bioentropy is thus *a reflexive source* of adaptation for operational conditions of living. At the same time, there is a finite amount of *potential* changes which the body is capable of achieving, and that whenever the body is achieving some one adaptive change, its ability to achieve any subsequent change is thereby reduced. Thus its *flexibility* is reduced. Species can get into trouble when stress creates contradictory demands upon some variable in total physiology. Such a double contradiction—the demand that the variable be increased to meet stress A and simultaneously increased so that stress B may be also be met—especially if the two stresses occur at different levels of overall organization [33].

"In biological evolution, adaptive changes occur during the lifetime of an individual (*i.e.*, phenotype), adjusting him or her to various forms of stress, efforts, demands placed upon skill and the like. What is consumed is (bio)entropy *i.e.*, uncommitted possibilities for change in many different physiological and neural variables and parameters. The uncommitted alternatives

((bio)entropy) are lost, eaten up by commitment and by becoming unchangeable parts of patterns. Adaptive changes limit the possibility for future adaptation in other directions."

Some biologists have taken Bateson to mean that he is supporting Jean-Baptiste Lamarck against Darwin, by supporting Lamarck's hypothesis that experience, performance and use of bodily parts, such as the giraffe using its neck to gain access to higher standing leaves on acacia trees, results in the long neck of the giraffe. Lamarck proposed that the flexibilities engendered through use of bodily parts are transmitted from parents to their young within a generation. Bateson did not support this idea at all. It was one thing to say that short term adjustments continually lock or restrict system performance yet if response to a stressed out system is subsequently inherited, as Lamarck proposed, then all Lamarckian heredity would do is to enforce ever increasing rigidity as it attempts to correct genetically the immediate errors in a parental generation. Such a result, over genetic time, would be a total loss of ability to adapt.

The real point worth supporting in Lamarck, Bateson says, is quite different to that ascribed to him. Lamarck recognizes that our bodies have perception and through perception, apperception or minimal intelligence. What we might observe from Lamarck's considerations is that our body is made up of a very large number of variables, which interlock in all sorts of spirals and loops, so that if organisms starts locking themselves into any one circuit of repetitive activity, the chances are increased that one spiral of tightening, one will *ipso facto* tighten the others. The individual can end up with no tolerance or flexibility anywhere (*i.e.*, "stressed out").

Ecological systems were systems which embodied meaning and hence the dilemmas that meaning always brings along *with* it. Bateson observed that all species will eventually run into conditions of contradiction arising from not only from unsuccessful phenotypic adaptation but, paradoxically, from successful systemic adaptation as well. In systemic terms, successful adaptation at one time might not be appropriate strategy to continue with at a subsequent time. The longer an adaptive characteristic continues to have positive survival value, the more this characteristic becomes entrenched in the organization of the creature, and the creature becomes less able to engage in evolutionary novelty. As he was fond of saying: *adaptation and addiction* are very closely related phenomena [34].

"Nature plays upon the well-adapted organism. For many generations she has let this organism act on the assumption that some of her (Nature) could be relied upon. The organism has been led up the garden path until it has incorporated into its deeper structure those factors which produced the adaptation... Nature encourages the organism to rely upon her and then shifts her tactics and says (you relied on me too much)..., a condition for evolutionary creativity."

Dilemmas of relationship also arise. Whenever ecological change brings dilemmas of relations, then these dilemmas about survival never remain simple dilemmas. Being second order dilemmas—or a dilemma inside a dilemma, nested dilemmas—they become dilemmas at one systemic level which cannot be resolved because of an unresolved dilemma at another level of the system which acts as "context" for the dilemma in question.

3. Aesthetics

3.1. The Difference That Makes a Difference

It was not until 1969 that Bateson himself had fully understood the path he had taken. His resolution went approximately like this: the initial problem he had worked on at the Veterans Administration Hospital in Palo Alto was how cybernetic signal events triggered meaning. Information sent and received in classical cybernetics was almost always as a physical signal in a circuit, such as instructions for technical machines, or as 'news' in a spoken or visual interaction between two people in human communication. These cybernetic events were enfolded in time series in a channel, the time series was 'error activated' so corrective action is brought about by the difference between some present state and some preferred state. In these situations, the technical term 'information' may be succinctly defined not only by feedback but by any difference which makes a difference in some prior event. This definition is fundamental for all analysis of information in cybernetic systems and organization.

Now, if information is considered as variety, as in Ashby's definition of information, and if the information event is some type of selection of form in variety, then there is a second order level of apprehension of messages, and a second-order level of intelligence typically is exhibited in animal communication. At second order level, the 'form' of the form is 'triggered by difference'. An information event at second order level not merely triggers error correction in a circuit, but through a form interacting with form (and not necessarily a linguistic form) generates a pattern of contrast or comparison, which embodies a difference, much as in any other type of communication. This difference indicates what the signal, or message is 'about'. Dealing with information at second order level, as the form of a form triggered by difference, yields a much wider concept than information in a feedback channel. It indicates that information, considered as 'difference', could emerge from the most simple acts of selection or comparison in any context of natural order [35].

"..., so long as we talk about difference do not pretend that difference is somehow 'physical'... difference is neither in the outside world, nor solely in the inside world but is created by an act of comparison and this act is an event in time—an act of scanning. Whether there are static differences 'out there' it is not so important for us as psychologists as the generalizing that only changes can enter into our perception. (And) that any difference which makes a difference is 'information' (there may be other differences, but these do not concern us as psychologists)."

And again [36]: "only news of a difference can enter into man's sense organs, his mapping, into his mind. Only difference can effect and trigger an end organ—so all our information (our universe of perception) is built on differences. Difference is 'super-natural' *i.e.*, outside the natural world as this is seen by the hard sciences. Difference is not located in x or y or in any space between."

If we consider Logical Typing as his preliminary method for discerning difference, his 'new way' he developed during the 1970s of dealing with information as the form of a form 'triggered' by difference gave an enormous flexibility to his whole construct. Bateson could now argue that 'message' or 'news' need not be tied to a specific circuit of senders and receivers. The triggering of 'difference' could occur in any information context through the simple means of comparison and contrast. These could include any means through which a process of perceiving difference occurred in

animal interactions or, beyond this, to organisms in the natural world. In short, information is the difference that makes a difference, and learning provides a framework of enquiry that is by no means exclusive to the human world but pervasive in the ecological world as well.

He could begin to think about contrasts in any form in nature, even how pattern is derived from contrasts and interconnection in morphology. The supposed mystery of patterning of form in nature adapting to its environment could now be seen to be the embodiment of difference in patterns of relationship of organism and its environment; and in these embodied patterns living forms recursively created their own organization.

3.2. Angels Fear

He carried this over into his final manuscript, half-completed at his death and which was published posthumously in 1987. The manuscript was a sketch of how a change in scientific ideas about its approach to nature might yield a more appropriate change in the way human relations respond to being participants in natural order rather than being aliens to it. A thumbnail summary of *Angels Fear* might be as follows: the book proposes a search for the unity of life, akin to the notion of the unity inherent in the unities of sacred aspects of life. The study of unity requires an epistemology, a set of procedures about how one might investigate the phenomenon of unity and derive a further understanding of holism, its order and its organization. Science rarely, if ever, deals with wholes. Those aspects of the world that scientific method cannot determine through its investigation of parts—that which is deemed to be unknown—is usually fobbed off into the realm of mystery and spirituality, and remains unexamined. This is non-science, more akin to seeking solutions in magic than in science [37].

He wished to orchestrate a return to holism on solid epistemological grounds. In an epistemological sense, one cannot use the strict tenets of reason in order to destroy reason without implicating oneself in a contradiction in terms. Indeed Jurgen Habermas raised this argument against the tactics of deconstruction used by Derrida. [38]. Nobody understood this lesson better than Gregory Bateson. To employ the tenets of reason to overthrow the universalisms of reason is to plunge oneself into the same sort of contradictions found in the Russell paradoxes of logical types. The contradiction could only be avoided if one finds a new way to relate particulars with universals. Only a modification of this fundamental relation between parts and whole will modify the ‘universals’ which the fragmented clarities of rationalism posit as ‘universals’ and thus change the epistemological characteristic of modernity—fragmentation—and of the science which had produced it.

To this end, he realized that he could not even use the science of systems science and cybernetic alone. He required rationalist science to recognize in biology and human society, as much as in physics, *indeterminacy inherent in the biological and social processes themselves.* This, in turn required the embodiment of contrasting conceptions of the interrelationship of the particular and universal. The mediating term was ‘aesthetics’. In *Angels Fear*, his posthumous publication, he establishes a deep connection between perception, aesthetics, and epistemology. Bateson drew the connection in terms of a forked riddle, a style of enquiry Warren McCulloch had often used: ‘What is man that he may recognize disease or disruption or ugliness?’ ‘What is disease or disruption or ugliness that a man may know it?’ The riddle’s two aspects derive on the one side from perceptual

acuity in recognizing a difference between beauty and ugliness, and on the other, an observer's knowledge of pattern of disease, and disruption.

Incorporating aesthetics meant neither acceptance of any particular spirituality nor the world-view of peoples expressed in their religious beliefs. Instead, it fostered the idea that unity and beauty were coincident with each other and that such holism should be an integral part of any modern science investigating the game of life. Both ecology and aesthetics are *immanent features* of our existence. Living systems are recursive systems. An ecological aesthetics at the very least gave insight into holistic patterns pertaining to the unity of life and provides a contrast to the *ad hoc* science of parts of patterns. Aesthetics was also a source of imagination and creativity; a resource against the possible jamming of information in Bioentropic change.

The attachment of aesthetics to ecology can be read in at least two ways in *Angels Fear*. The first is that of a metaphor for unity contained in the idea of an ecosystem, an aesthetic sensibility to pattern and modulation of pattern—that becomes the material for dream and poetry [39]. The other comes about through a deep connection between epistemology and aesthetics. An ecological aesthetic gives rise to ideas about unity. Thus, aesthetic ideas must be brought to an interface with an epistemology in order for systemic thinking about feedback and ecosystems to occur. Once the domain for an ecological aesthetics is confirmed, then epistemology itself requires attention. In this phase a modification of fundamental relation between parts and whole will modify 'universals' or those fundamentals of rationalism that science posits as 'universals' when they are in fact merely fact fragments.

Since any recursive communication system must become aware of fragmentation and tearing apart of its fabric of unity, developing an ability to perceive patterns of part-whole relationships is a means through which ecology become a subject which investigates itself in a rigorous way in order to achieve as holistic perspective as possible. The first step is to acknowledge systemic discrepancies which necessarily exist between what we can say and what we are trying to describe. This indicates becoming aware of the myths by which we live and the way in which these myths help establish a pattern and habit. The myths of dualism, mind separate from matter, body separate from mind, environment separate from cultural tradition are among the most conspicuous of these myths in both science and the humanities, as too, is the practice in science of separating of parts from the whole. Second, the epistemological work attached to aesthetics must examine how mind creates its mapping of the world, and how often the map is mistaken for territory [40].

3.3. Aesthetics as Meta-dualism

Like any epistemologist whose opposition to dualist explanation is so consistent and complete, Bateson has to develop an explanatory scheme that is meta—to dualism. C.S. Peirce accomplished this with his triadic conception of Firstness-Secondness and Thirdness. One can find scattered references throughout Bateson's writing to images of 'thirdness', but while there was little or no attempt in Bateson's writing to elaborate a methodology of triangulation in support of his triadic concepts such as the Coast Guard officer and logician Charles Peirce so elaborately produced, there was in Bateson's writing always consistent references to a logic of 'in-between' part and whole. One iconic example that Bateson used was that of a hologram, where each part of a hologram also registered an image of

the whole hologram, though indeterminately. Another was that of a peculiar form of textile preparation called *moiré* [41].

"In principle, all resonating systems (*i.e.*, living systems) have hologramic characteristics. The simplest case is that of the interaction between sounds of different frequencies which generates beats. More complex examples arise is so called *moiré* patterns. When two repetitive systems combine, a third is necessarily generated."

There is no guarantee for any observer that these patterns of thirdness are going to appear on their own account. As in the intricacy of textile production of *moiré*, the senses have to be disciplined and skilled before the patterns can be perceived, let alone produced. Moreover, Bateson admits, pattern of aesthetic percepts do not flow easily into the pattern of epistemology and numerous tensions lie in the fork between the two. At the outset there are issues of perception stemming from seeming contradictions in the very task of perceiving patterns. Next there is the tension between appearance (ecological change) and descriptions of 'reality' applied to appearances. Nevertheless, a new way of seeing recursion in the realm of aesthetics could, as Bateson suggested, encourage an individual to see how the natural order embodies its own tautologies or mutual causality—"that special sort of holism generated by feedback and recursiveness" [42].

He marked his aesthetic epistemology as combining both 'rigor' and 'imagination' [43]. 'Rigor' and 'imagination' become Bateson's meta-logical types and aesthetics his meta-dualism. Epistemological 'rigor' would proceed from the understanding that all recursive communication systems must become aware of disruption in its own relations, even though various systemic discrepancies necessarily exist between what we can say and the unknowns that we are trying to describe. At the same time, the sources of imagination in a human mental system are very diverse indeed. He describes them as metaphor, dream, parable, allegory, the whole of art, the whole of science, the whole of religion, and the whole of poetry, totemism, and the organization of facts in comparative anatomy. The list goes on.

Significant to Bateson's approach to the marriage of ecology and aesthetics was the writing of the British artist and philosopher R.G. Collingwood. The idea of the "Imaginary" lay at the centre of Collingwood's aesthetics. Collingwood argues that it has been commonplace for several centuries in western thought to confuse the imaginary with false sensation or with the illusions of 'make believe'. Nothing could be further from the mark. *Imagination* is a form which emotion or feeling can take when transformed by the activity of consciousness. Imagination, lies partly between sensa and thought; it is not sensa directly but is sensa in respect of which the interpretative work of thought has done well, or done ill or left undone. "A real sensum means a sensum correctly interpreted; an illusory sensum, one falsely interpreted. And an imaginary sensum means one that has not been interpreted at all; either because we have tried to interpret it and have failed, or because we have not tried..." [44]. One scholar termed Collingwood's discussion of the imaginary as introducing 'ideated analogues.' It is a forceful expression, for as Collingwood argues, the imaginary is very close to standard notions of 'an idea' [45].

"There must be... a form of experience other than sensation, but directly related to it; so closely as to be easily mistaken for it, but different in that colour, sounds, and so on which in this experience we 'perceive' are retained in some way or other before the mind, anticipated, recalled though these same colours and sounds, in their capacity of sense, have ceased to be seen and heard. This other form of experience is what we ordinarily call imagination."

Both Collingwood and Bateson had major interests in understanding how perception and imagination lie in the gap between feeling and intellect. They both agreed that perception and emotion are not rendered in concepts about abstracted immediacy, used in explanations by the empirical philosophers. Locke notwithstanding, perceptions may be fleeting phenomena which derive from the senses of touch, smell, sight and so on but the point at issue is that sense alone—sense data, or impressions, are never sufficient for aesthetic expression. Before that which we would call 'thinking' takes place there must be additional sequencing, reflective moments of experience, which can be described as the return of the mind upon itself to the primary occurrences in mind. It is feedback of the reflective mind upon itself which renders conscious attention on the experience [46]. As one student of Collingwood put it "if I hear a bell striking the hour (to be aware of it) as a process extended in time with a particular morphology, I must retain the sound of the bell, along with the silences in between... the faculty of conscious attention generates ideas corresponding to the sensa, and which are then retained. Sense alone—or sense data—or impressions are never sufficient for consciousness" [47]. Thus perceptions are simply a primary experience, which conscious attention then seeks to render explicit that which is implicit in the experience itself.

For Collingwood, a work of art is not seen or heard in the usual way but is imagined. The sensuous and the emotional combine according to a "definite structural pattern" something more that mere substructure upon which thought of truth, falsity or illusion rests. In other words the aesthetic dimension organizes an imaginary order, a whole realm of understanding which occupies thought [48].

"The activity of consciousness... converts impression into idea, that is crude sensation into imagination... Imagination is thus the new form which feeling takes when transformed by the activity of consciousness... (Note) consciousness is not something other than thought, it is thought itself; but it is a level of thought which is not yet intellect.

Elaboration of the imaginary is both an individual and communal (collective expression) of ordering perception, Collingwood claims, for the artist is by no means an errant genius, but always works with and out of the sentiments of community. In effect, Collingwood's aesthetics gives grounding to the relation that Bateson had always drawn between a 'percept' and an 'idea'. Collingwood claims that most theories of beauty falsely locate the activity of aesthetics, by thinking of aesthetics as a representation of external 'beauty'. Philosophers and the public at large seemed to believe that the aesthetic experience was initiated through the reaction of an artist to a specific stimulus from the external natural world. To the contrary, appreciation of the beauty of nature came from *within the artist* and is autonomous, involving a variety of coincident responses. Contrary to popular belief, artists do not imitate nor does art 'represent' in any simple manner; any given representation is always a means to an end. "A representation may be a work of art, but what makes it a representation is one thing, but what makes it a work of art is another" [49]. Instead of a direct transfer of sensation through consciousness to 'thought', he finds that the relation between the act of feeling and what we think is different in kind. Moreover, the relation between the act of thinking and what we feel becomes transformed as it proceeds towards becoming aesthetic knowledge. For "the experience of feeling is a perpetual flux in which nothing remains the same and what we take for permanence or recurrence is not sameness of feeling at different times, but only a greater or lesser degree of resemblance between different feelings" [50].

Another way of putting this is to say that perception enables distinction to be made between pattern and noise, as Bateson argues. The primary means for discrimination is that of perceptual comparison, in contexts for comparing changes continues in an imaginary perspective. So imagination, the imaginary in Collingwood's sense, works away at the fork of contradictions in the interface between aesthetics and epistemology. Perceptually this will draw individuals toward an awareness of beauty in a larger more inclusive system.

The following exchange is indicative [51]:

Question: Would it be correct to suggest that the aesthetic is this unifying glimpse that makes us aware of the unity of things which is not (in the limited sphere of) consciousness?

Gregory Bateson: That is right; that is what I am getting at. The flash which appears in consciousness as a disturbance of consciousness is the thing that I am talking about.

It becomes a disturbance of consciousness because consciousness as a manifestation of prose or scientific description tends to focus inwards, whereas notions like the sacred and the beautiful tend to be always looking for the larger, the whole. Aesthetics, the unifying glimpse, provides a medium through which humanity can begin to communicate about how to understand wholes and thus the unity of the biosphere. Otherwise a science of ecology, and Bateson's *modus vivendi*, an "ecology of mind", will be bad cybernetics, bad science, and bad semantics [52].

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