T-206

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2

On Brain and Value: Utility, Preference, Play and Creativity

Karl H. Pribram
Center for Brain Research and Informational Sciences
Radford University
Box 6977 - R U Station
Radford, VA 24142
Telephone: 540-831-6108 / Fax: 540-831-6236
E-Mail: kpribram@runet.edu
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Abstract

At the Fifteenth International Congress of Psychology held in Brussels in 1957, I presented evidence from primate studies regarding the biological determinants of values. I stated then:

> "the empirical relations that determine the value of a piece of currency depend, in part, on the utility of that piece of currency for any individual. The currency used in the primate neurobehavioral experiments reported was a food pellet or peanut. Two interrelated classes of variables have been abstracted by economists to determine utility: demand and expectation; two similar classes (need and probability distribution) can be delineated from the experiments reported here -- each of the classes related to a distinct neural mechanism. A still different neural mechanism has been delineated whereby (preferences among) values can be discriminated." (Pribram, 1957, p. 82)

What follows here is an updated version of these findings and analyses, which provide the prologue to and organizational framework for the Proceedings of the Fifth Appalachian Conference on Behavioral Neurodynamics.

Familiarity

Take an often repeated experiment. Five hundred pictures are displayed for observation, then mixed with 500 others portraying somewhat similar subjects. Next the full set of 1000 pictures is displayed, and the observer has only to indicate which pictures are familiar and which are unfamiliar. Most of us perform this task with a remarkable 90% or better score.

Next we encounter a patient who experiences bizarre (to her) feelings of familiarity in places she is sure she has never been. Another patient complains that he has just the opposite experience: He comes home only to feel it, on occasion, to be strange and unfamiliar to him. These feelings of "deja" (already) and "jamais (never) vu" (seen), as they are called, are related to epileptic electrical discharges recorded from the region of the amygdala, an almond shaped basal ganglion (the Greek for almond is amygdala) central to the functions of the limbic systems (limbus means border -- the limbic portions lie on the medial border of the cerebral hemispheres).

Such epileptic seizures, when they are prolonged, can prevent a whole episode of experience from becoming a part of the familiar narrative by which we experience our continuity as selves. Similarly, when the amygdala of both hemispheres of the brain are removed, monkeys no longer perform adequately on tasks comparable to those which test for familiarization in humans (Douglas & Pribram, 1966; 1969; Pribram, Douglas & Pribram, 1969).

Familiarization is an odd process. Confronted by a novel event organisms manifest an orienting reaction. When such an event recurs repeatedly, the orienting reaction subsides (habituates) after some 3-10 repetitions. After removal of the amygdala, however, the orienting reaction continues and continues and continues. Familiarization fails to occur.

The orienting reaction has, in addition to obvious behavioral orienting toward the novel stimulus, visceral components. Heart rate, blood pressure, and respiratory changes occur, as well as changes in brain electrical recordings. Such changes are produced by electrical stimulation of the amygdala and the cortical systems related to it (Kaada, Pribram & Epstein, 1949; Pribram, Lennox & Dunsmore, 1950). After amygdalectomy the visceral components of orienting no longer occur. Neither does familiarization: as noted, behavioral orienting continues (Pribram, Reitz, McNeil & Spevack, 1979).

From these observations we may conclude that familiarization depends on the occurrence of visceral reactions which are processed by the amygdala and related limbic systems of the brain. Further, on the basis of this and other evidence, we can conclude that each familiarization consists of an episode initiated by an orienting reaction to a novel event and terminated by the next experienced novel event.

Novelty as Rearrangement

What then might be experienced as a novel event? Again, experiencing novelty is an odd process. Novelty turns out to be experienced when a rearrangement of, or minor change in, the familiar takes place. Productive invention is based on a thorough familiarity with the inventory at hand. Reinventing the wheel is not innovative. A literary novel is composed of nuances, repeated small changes in the familiar which carry the plot gradually forward. If novelty were entirely unexpected, *Reader's Digest* would not be able to delete whole sections of the manuscript.

An experiment performed in Belgium (Smets, 1973) makes the point succinctly. Humans were shown two types of changes in displays while changes in visceral measurements were recorded. One change in display radically increased or decreased the amount of information; the other merely rearranged the items in the display. Practically no visceral reactions were recorded when the amount of information was changed. By contrast, rearrangement produced marked visceral responses. It is these repeated rearrangements of the familiar that elicit such strong "gut reactions" from music as well. (Pribram, 1982; Pribram et. al, 1966).

Thus, the experience of novelty is produced by rearrangement and change of the familiar. In turn, however, the experiencing of the familiar depends on novelty: Without novelty, the familiar recedes from consciousness. We walk through doors, giving the surrounding walls nary a glance -- unless an earthquake shakes up the familiar into novel configurations.

In more ordinary circumstances there are occasions which also demand this shaking up of the familiar in order to invent, to create novel configurations in our conscious awareness. Fortunately there is another part of the limbic brain, the hippocampus, lying just behind the amygdala, which makes such internal shake-ups possible. Damage to this sea-horse-like structure (hippocampus is Greek for seahorse) in humans makes it impossible for them to resist a practically total wipe out of current experience every time a novel (distracting) event occurs (Pribram 1986; 1991, Lecture 9)

Events as Consequences

Understanding novelty as a change in the familiar is the key to understanding values. Evaluation of an "event" or "eventuality" is achieved by activating (dishabituating) a previously familiar, tacitly known (see Polyani, 1960) aspect of a situation. The novel <u>event</u> is the <u>outcome</u>, the <u>consequence</u> of the process (Bateson, 1976; Konrad & Bagshaw, 1970). In fact the word event is the derived Latin equivalent of outcome: ex (out) - venire (come).

How are events, the consequences of habituation and dishabituation of the novel and familiar achieved? Let us first examine a biological paradox. Our respiratory mechanism is based on the ability of our tissues to metabolize food in the presence of oxygen. Without oxygen we quickly cease to live. However, the neural control over respiration is practically insensitive to oxygen deprivation -- lack of oxygen is reflected only minimally, if at all, in a change in respiratory rate, discomfort or alarm. By contrast, very minute changes in the partial pressure of carbon dioxide -- the end product (with water) of our respiratory metabolism -- are sensed by cells in the brainstem which, when carbon dioxide accumulates, initiate increases in respiratory rate, feelings of discomfort and even alarm.

This illustration is but one example of the fact that biological control mechanisms are often indirect and circuitous. Sexual selection takes place for the pleasure it provides but assures diversification and survival for the species; food is chosen on the basis of taste but accomplishes the maintenance of energy sources for the organism; clothes are donned for adornment but protect against weather, etc. The immediate control over behavior is exerted by a mechanism that is remote from the biological significance that the behavior entails.

Utility and Futility

There is evidence from the results of brain research that this universal biological paradox applies to the effects of the consequences of behavior on the organization of human values as well. Some fifty years ago I noted that monkeys whose brains had been subjected to removal of the amygdala would place all sorts of objects in their mouths, chew on them and if they were chewable would swallow them (Fulton, Pribram, Stevenson & Wall , 1949; Pribram & Bagshaw, 1953). We first wondered if the animal's taste mechanism had been disturbed and showed that their primary taste preferences were intact and that the area of the brain responsible for primary gustatory sensation was located elsewhere (Bagshaw & Pribram, 1953). We next wondered whether some higher order system of preferences had been disrupted by the resections of the amygdala -- that "good taste" had been abolished and gourmet had been turned into gourmand. But careful testing showed that the order of choosing food and non-food objects had not, in fact, been altered. What was preferred before the brain operation continued to be preferred in just the same order following the operation.

Preferences show transitivity -- they are hierarchically arranged -- utilities are not. One can prefer vegetables to meat, but it is difficult to choose one child's wellbeing over another's. For the lesioned monkeys the cutoff point for continuing eating was changed. The monkeys with brain lesions accepted a much wider range of objects before they stopped eating (Wilson, 1959; Weiskrantz

& Wilson, 1958). More elegant experiments demonstrated that chemical stimulations of this part of the brain (the amygdala) though they would not initiate behavior, would regulate the amount of ongoing eating and drinking, the amount varying precisely with the volume of chemical injected (Grossman, 1967; Russell, Singer, Flanagan, Stone & Russell, 1968). In short, this part of the brain quantitatively controls the consequences of behaviors that satisfy one or another biological need once these behaviors are initiated.

The brain processes directly in control of need satisfaction (see Livesey, 1986 for a comprehensive review) lend themselves to classification into three major categories (Pribram & McGuinness, 1975; 1992). The processes just discussed that stop behavior and regulate the amount of the consequential behavior constitutes but one of these categories. Another process (centered on the basal ganglia of the forebrain -- see Pribram & McGuinness, 1975 for review) readies the organism to behave in a certain manner and initiates the consequential behavior. A third process (based on the hippocampal formation), coordinates these stop (familiarization), and go (readiness), processes into a smoothly functioning system to operate within certain limits of tolerance. Coordination takes effort and shifts the type of control from a closed loop feedback homeostatic to a helical open loop feed-forward process. I have detailed elsewhere (Pribram, 1971, 1975a, 1992, 1997) the evidence that feed-forward processes are the basis for intentional behaviors and for that special human ability philosophers call "intentionality". (Intentionality stands in relation to perception as intention stands to behavioral performance. Both intentionality and intention share the characteristic that they are about the external objective world but need not be realized in it.)

When effort reaches limits of tolerance, coordination breaks down and the organism reverts to homeostatic control. Under such circumstances homeostasis may also fail to work efficiently (Ashby 1960), with the result either that the organism experiences, a) upset due to loss of control, or b) obsession, compulsion or boredom due to attempted overcontrol. The management of upset and of overcontrol are continuously faced in the psychiatric clinic and in everyday life by clinical psychologists. Understanding can be framed within the "utility" theory of economic behavior and "futility" theory to deal with the "games people play" such as that proposed by Berne (1961) to deal with upset, compulsion and boredom.

Some Economic Theory

In their influential volume on the theory of games and economic behavior, Von Neumann and Morgenstern outline the elements of a quantitative approach to the problem of value based choices that regulate competitive behavior (Von Neumann & Morgenstern, 1953). In common with other economic theorists, they distinguish behavior that 1) meets the needs and desires of the individual; 2) his estimate of the probability that the occurrence of the need-satisfying behavior will in fact meet a particular need; and 3) the construction of a preference hierarchy from 1 & 2. Needs and desires are measurable in terms of the amount of behavior entailed in their satisfaction, provided a zero point or anchor and a scaling of increments of that behavior become available. Von Neuman and Morgenstern use the illustration of measuring temperature. A zero point must be chosen (e.g., the freezing point of water) and a scale (e.g., adding a portion of a quantity of heat to raise the temperature to the boiling point) developed. Measurement is relative to the zero and scale chosen unless some absolute zero is discerned and agreed upon.

Von Neuman and Morgenstern's theory reflects some of the brain biological facts outlined in the previous section. The experimental analysis of the mathematical principles regarding reinforcing, i.e. consequential events: How these two factors operate and interact was shown by Peter Killeen in his presentation at the Fourth Appalachian Conference on Behavioral Neurodynamics in 1996 and in his earlier presentation (1994) in Behavioral and Brain Sciences:

1) Needs: The evidence for a measurable, filtratable process regulating needs is provided by the carefully chemically titrated satiety process delineated by injections into the amygdala noted above (Russel, Singer, Flanagen, Stone & Russel, 1968).

2) Probabilities: The evidence for a process that estimates the probability that the consequences of behavior will provide satisfaction of a biological need comes from studies comparing the results of food deprivation with those of produced by frontal lobe resection. Using the fixed-interval operant conditioning technique, I showed that monkeys deprived of food would change the rate of responding without changing the distribution of responses across the interval. By contrast, monkeys with resections of the most forward portion of their frontal lobes would fail to distribute their responses probablistically, whereas intact monkeys would (Pribram, 1961).

In terms of human endeavor, we have all observed that students tend to distribute their work between examinations so that maximum activity takes place just before the critical moment when tests are given. We urge them to plan differently -- but the experimental result obtained with monkeys described above suggests that if they were deprived of their frontal cortex, the distribution of activity would cease and the students would come completely unprepared for "the moment of truth". In fact, patients with frontal lobe tumors or excision behave in just this fashion -- unable to plan, to distribute their responses according to an estimate of the probabilities that the responses will be effective.[1]

Games and Play

3) Preferences: But life is not a game, especially not a zero-sum game. Humans are creative and find ever greater opportunities for making their behavior eventful and consequential. Witness Hong Kong, a rocky island (and small peninsula) that has become one of the great ports and trading centers of the world through sheer innovative effort. Life is open-ended, akin to a play: Shakespeare stated it so clearly: "and all the world's a stage".

Games are closed systems where control is exercised by way of feedback processes called homeostasis that operate much as do thermostats. Over the past decades, investigators (Ashby, 1960; Mackay, 1962; Mittelstaedt, 1968; Pribram, 1971 Chapter 5; Pribram & Gill, 1976, Chapter 1) have begun to distinguish between feedback organizations that are error-sensitive (such as simple thermostats) and those whose settings can be controlled. In a thermostat a small wheel is usually attached which alters the gap between two pieces of metal which, when they touch, close the switch that turns off the heat source. Heating the metal also closes the gap -- thus the critical distance between the pieces of metal is controlled by two sources operating in parallel, heat and the dial setting. The dial provides a bias on the setting, thus a range of settings can be programmed around which the ambient temperature (the measure on the amount of heat) will fluctuate.

These biasing mechanisms have become known as information processing mechanisms especially in their parallel distributed processing (PDP) form. The organization of information processing is open loop or helical rather than closed as in the case of feedbacks. Information is processed because pattern matching is involved: The furnace is to be turned on or off, just as in the

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[1] And we have recently obtained evidence that the frontal part of the brain is still maturing as late as 18 - 21 years of age (Hudspeth & Pribram, 1990; 1992).

case of feedback organization. However, the turning on and off is no longer based solely on error processing, the differencing between a current and an inflexible desired state. Rather, the desired state is programmed by the dial. To the extent that the dial can be turned to a range of settings independent of the current temperature, the mechanism feeds information forward to control the process. As noted, the hippocampal formation makes possible such a shift from a feedback to a feedforward process. A model of how this shift is made has been developed (Pribram 1991, Lecture 9; Pribram 1997). For here the important consideration is that the model in involves an interaction between the hippocampal formation and the cortex of the cerebral convexity to which we turn next.[2]

Preferences and Prejudices

Rather than the frontolimbic parts of the brain considered so far, it is the posterior convexity of the brain which, when injured, affects choices among situations (Pribram, 1969; See review in Pribram, 1991, Lecture 7). Analysis has established that such choices, discriminations used in animal research, are akin to those involving preferences as these describe human choices (see the seminal review by Irwin, 1958). There is thus substantial evidence that the brain systems involved in establishing preferences are separate from those regulating utilities through probability estimates of the satisfaction of biological needs.

How are preferences developed? As human primates we go about our activities estimating the probability that particular needs will be satisfied. For example, after a tennis game we are thirsty and set to drink a specific quantity on the basis of the tissue osmolarity, the "concentration of water" (or of the electrolytes dissolved in the water), which is sensed by the brain. On the basis of prior experience, we either gulp down the required amount of liquid rather indiscriminately, or having on several occasions experienced cramps as a result of drinking too rapidly or because the liquid was too cold, we sip more casually instead, sitting down to share a leisurely afternoon iced tea or relaxing alcoholic beverage.

But it is peculiarly human that we might never have had the experience of cramps induced by too rapid satiation of thirst with inappropriate liquids. We might simply follow the guidelines for appropriate behavior given to us by our care-taking elders or our peers. We then say that we *prefer* the civilized behavior that is defined by sipping drinks at our tennis club. Again, nature's paradox

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[2] The model involves a content addressable holographic-like matching between current input and stored memory. The model is based on evidence obtained with microelectrode recordings made within the hippocampal system and within the somatosensory cortex of the parietal lobe (Pribram, 1997).

A holographic process is based on the distribution of, and therefore enfolding of, information over and within an extent (a spatial and temporal envelope). In economics, the marketplace is such a holographic structure: each transaction enfolds the values of the whole, which are distributed throughout the extent of the whole. Thus, when one spends a unit of currency -- say a dollar -- the current value of that unit (currency) represents the productivity of Japan, China and other far eastern economies, the adjustments of European nations to a common market and common currency, the appearance of cow disease in England, the Wall Street Stock Market, etc.

In the same fashion, the current valuation of an event occurs within the marketplace of the episode within which the event is generated. Valuation thus depends on the values attributed to the variety of transactions that compose the episode.

shows itself: biology, in terms of brain processes, substitutes civility for direct action to achieve utility.

I believe that this example can be generalized to a description of how human preferences come to be organized. *The experienced utilities (and futilities) of individuals become encoded in culture to be presented to others as preferences.* Preferences are, from time to time, checked against utilities by individuals or by groups of individuals as in the recent revolutionary decade of the 1960's and again in Europe in 1989. Alternatives were explored, and if the situation has changed sufficiently (e.g., the advent of the birth control pill and Michael Gorbachev's decision to withhold troops) new preferences may emerge.

To summarize: Both theory and brain research make a good case for distinguishing between utilities and preferences. Utilities are based on biological needs, quantitative controls over the behavior based on *internal controls* which are subject to probability estimation of their satisfaction based on covariation among encoded experiences. Preferences, by contrast, devolve on a separate and distinct process which involves the ability to discriminate between invariant *situations*. In short, *utilities are state and situation specific and thus context dependent, whereas preferences are situation general hierarchically arranged and context free.*

Ethics and Morals

In ordinary life, experience controls the bias on the homeostatic regulations of the organism. Ordinarily, the eventualities are taken into account, and the response appropriate to the occasion is computed. Unless addicted, we ordinarily also take into account the limits over which control can be exercised before breakdown or futility occurs. Thus, eventual risk and cost-benefit ratio are considered. These considerations are state dependent and thus direct the attentions and intentions of the organism.

However, different situations may induce different states and therefore different utilities. But as situations may resemble one another, identities can be assigned to guide intentions. In most physical situations identifications work well. They are the basis of classifications in terms of attributes. (See review in Pribram, 1991, Lecture 7.)

Nonetheless, identifications can be assigned inappropriately. An experimental demonstration illustrates this point. Subjects are asked to describe the pattern of lights switching on and off in a matrix of possible positions. The descriptions are rated as closer to (warmer) or further from (colder) correct. But both the switching of lights and the ratings are in fact given randomly. Despite this, most subjects come up with ingenious descriptions of the paths of light placements -- some of these descriptions are incredibly complex.

Such misidentifications abound in social situations. Once an identification has been made, the subject defends it against dissolution despite being given additional information (such as "the appearance of the lights was actually random" or "I gave you hints as to colder or warmer randomly"), perhaps because putative correlations were not strained beyond credibility. Thus, preferences (in contrast to utilities) become automatized (Pribram, 1975b). They are not computed anew for each situational episode since they are grounded in the putative invariances obtaining in the situation, not its variety.

There is danger in this. Automatized preferences in social situations are difficult-to-change prejudices.

The distinction between utilities and preferences finds an echo in the psychoanalytic distinction between ethics and morals. Otto Rank (1936) suggested that ethics (based on relations to the mother) are internal feelings based on covariation among events, the eventual consequences of our behaviors. By contrast morals (based on instructions provided by the father) are external given that fit one to society. Gilligan's research (1982) has supported this difference between the development of male rule of governed morality and the more flexible ethical development of females, and Hayek (1988), in his book *The Fatal Conceit: The Errors of Socialism*, has described how societal morals become established.

The moralist does as (s)he should; whereas ethically we explore our wants (utilities and futilities). The moral person uses his moral preferences (and prejudices) automatically -- that is, without analysis, to support his intentions. The ethical person, paradoxically, analyzes each valuation with respect to his or her wants. The moral person invokes God or other ideology to support his preferences in a dispute; the person on the other side of the dispute is equally certain that God supports his/her opposite preferences. The ethical person intuitively feels and therefore recognizes that his/her wants (i.e., internal utility states) are situation specific and context dependent and thus may not be those of the other person. Much of psychoanalytic procedure is devoted to loosening morally given "shoulds" so that ethically determined "wants" can become realized. In social situations, wants, i.e., utilities and futilities, are negotiated by the interplay between a person's own wants and those of others. Such interplay frequently evokes paradox as when former rivals emerge as staunch friends.

Paradox and Wisdom

The results of this biobehavioral analysis return us to the biological paradox described at the outset of the analysis. Just as in the brain's control over respiration, feeding, drinking and sexual behavior, the control of the organism's values is ordinarily accomplished by way of his preferences. These are situationally derived and *appear* to be inviolate because they reflect putative invariances across situations. Man is thus shaken when he finds his preferences dissolving under the onslaught of major situational change. He is forced to relinquish his automatic mechanisms of information processing and rely on the computation of covariances (Pribram 1991, Lecture 10) from one episode to another. Such computations entail risk (the dangers of futility) as we have seen, and are thus likely to be accompanied by upset, and countered by overcontrol leading to dogmatic reassertion of an absolute which has become obsolete, or by relinquishing of all values leading to anomie and anarchy.

Does this mean that there are no universal values? Of course not. It means only that, understandably but paradoxically, we have identified universals with our preferences rather than with our utilities and futilities. The paradox consists of the fact that utilities, since they deal with episode and state dependent variables, *seem* so unreliable. But as long as episodes do not differ catastrophically, and as long as the brain's computational machinery is universal to all mankind, universals *can* be derived from such computations. In fact, as we saw above, preferences are often a cultural representation based on computed universals. Carl Jung (1968) referred to the utilities upon which such universals are established as archetypes.

The paradox penetrates further. Identifications signifying preferences constitute knowledge, especially scientific knowledge. (The terms science is derived from the Latin *sciencia*, to know). Knowledge at any moment is, therefore, finite, bounded by the limits that describe the situations over which the identifications hold.

Computations of covariations among recurring episodes have no such bounds. Variety can be as infinite as possible covariations, as infinite as the reach of the brain processes involved. Changes in biological states and major shifts in situations continuously reset the process as long as life lasts. Resetting removes prior established limits and often results in solutions that appear to be paradoxical and even enigmatic -- just as in mathematics dividing a line of unlimited ("infinite") length results in two lines of unlimited ("infinite") length -- thus one half equaling the whole. Ordinarily we speak of processes that involve such paradoxes as demanding wisdom for their resolution (Pribram 1971, Chapter 20).

Wisdom is at home with paradox. Solomon's apparent cruelty in dividing a baby in two proved the humane solution to a difficult dilemma. The mother's "giving up" her infant paradoxically resulted in her retaining it as is so often the case in interpersonal transactions. G. Spencer Brown in his *Laws of Form* (1972) provides a mathematics for handling paradox by "inventing" an imaginary Boolean descriptor. Spencer Brown addresses the Russell-Whitehead paradox ("I am a liar") but his formulations are applicable to a wider range of problems in the domain of the infinite.

Wisdom is thus based on acknowledged change produced in an unacknowledged, tacit familiar context and are therefore guided by the familiar. Nevertheless such change can take many forms. What makes for successful change? To answer this question we turn again to the part of the brain that is involved in controlling the probabilistic distribution of consequential behavior. As we have seen, this part of the brain, the anterior frontal cortex, integrates the processes that involve the amygdala and hippocampal systems.

The far forward portions of the frontal lobes of the brain serve this controlling function in the following fashion. The lower orbital part of the lobes, seated above the eyeball, are directly connected with the amygdala; the upper part is connected with the hippocampus; while the middle parts connect with the rest of the brain. Experiments performed with monkeys and observations made on humans have shown that the lower parts of the lobe are involved in dealing, on the basis of familiarity, with the propriety of actions to be undertaken. The upper part of the lobe arrange the priority of the actions taken on the basis of their effectiveness. Finally the mid portions of the lobe integrate propriety and priority into a practical course of action on the basis of probability estimates of the success or failure of its consequences. Consequences, sequences of events, outcomes of actions, when they are novel, produce visceral responses until satisfying familiarity is established. A succession of novel events can thus become familiarized as a narrative, a story which serves on subsequent occasions to guide inference as to proprieties, priorities and practicalities. The inferences are not reasoned in any logical sense; rather they simply accrue probable practicality from prior experience. The valuation is intuitive.

Thus, one way of summarizing the results of this neuropsychological analysis is to state that preferences reflect hierarchically organized information processes that lead to knowledge: the identification of finite invariant properties of situations. By contrast, the processing of utilities and futilities spawns wisdom: the processing of paradox among an infinite variety of narratives. In keeping with this rootedness in paradox, wisdom, though in the realm of the infinite, is not unfathomable. Slowly it is yielding the secrets of its structure to scientific knowledge while carefully harboring its contents. For wisdom is displayed in parables in an infinite diversity that paradoxically unifies our humanness.

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