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Method for Theory: A Prelude to Human Ecosystems

H. E. Kuchka

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Inscription on a bridge at the Summer Palace of the former Emperors of China

There are three monkeys who cannot see their faces.
There is a bridge but no water.
There are windows but they do not open.
There is a tablet but no words.
There is a mirror but you cannot see your face.
There is a gate but no one passes through.

Truth in Advertising:
The following essay is a somewhat twisted mimicry of Pickett, Kolasa and Jones 1994.

Preface

This two-part essay represents the product of an exercise in developing method for theory, beginning Fall 1999 in the Complex Systems II graduate seminar in the Department of Anthropology at the University of Georgia. It was motivated by dissatisfaction with both the understanding and practice of theory building presently available in ecological anthropology. We sought to integrate an expansive approach to method-for-theory with our developing human ecosystems perspective.

We needed a strong method-for-theory to provide a common framework for our diverse interests in human ecosystems. *Ecological Understanding* (Pickett, Kolasa and Jones 1994) was chosen as the model exposition. As a guiding model it is an excellent place to begin. Cleverly done, well organized, easy to read, it misses very little about the nature of theory relevant to biological ecology. Our immediate goal was to rework its structure and content in the service of human ecology, particularly to enhance our approach to human ecosystems.

The author of this essay is given as H. E. Kuchka. H. E. is the abbreviation for Human Ecosystems. Kuchka is *the group*.[1] This moniker was inspired in part by the character and creative spirit of the late 19th Century musical study group in Russia that included Rimsky-Korsakov, known in the West as the Mighty Five. Our group's ultimate goal is to establish a truly anthropological understanding of human ecosystems, drawing upon a broad range of human variation and historical perspectives, while at the same time adapting the compositional techniques and scholastic backgrounds of other, more mature, ecological disciplines.

Felice S. Wyndham, Guest Editor

[1] In this production it was Felice S. Wyndham, Eric C. Jones, Mitchell A. Pavao-Zuckerman, Suzanne E. Joseph, Rebecca K. Zarger and Charles R. Peters, with contributions from David G. Casagrande, John R. Stepp and Warren P. Roberts.

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INTRODUCTION: INTEGRATION IN HUMAN ECOLOGY

Two themes will be addressed throughout this essay. The first is that there is both a need and an opportunity for greater integration in the discipline of human systems ecology. The second is that the tools are already available to achieve greater integration, especially if it is recognized that human ecosystems are predominantly evolving and dynamic information-ecosystems. Our task here is to conceptually explore the implications of this realization, in search of a broader understanding of the nature of human ecosystems. But first we must lay out a framework for the development of theory in the service of disciplinary integration. Toward this goal, this essay is divided into two main sections. The first section is concerned with the methods and rationale for developing integrative theory in human ecology. The second section applies these methods to sketching some of the components of a nascent theory of human ecosystems, our initial working experiment in the utility of disciplinary integration in human ecology.

The task of understanding humans has traditionally been rather strictly divided. The humanities study the informational aspects of human societies–art, religion, literature, history–while biologists and a few ecologists and anthropologists tackle physical, medical, behavioral and cognitive components. We propose that to begin to understand human systems, a human ecology paradigm[2] must be developed that integrates these two historical trajectories. The discipline of anthropology has been at the intersection of these two trajectories since its conception and is thus a good place to prescribe the radical integration of sociocultural ecology and biophysical ecology.

To get a feel for what an integrated human ecology might look like we offer the following introductory preview. After examining each on its own, try to look simultaneously at the four graphical conceptualizations of human systems presented in **Figures 1a** through **1d**. The goal of this exercise is to promote the kind of radical synthesis needed for a truly integrated human ecology. Each of these models adds unique conceptual constructs and graphic representations of the problems and potentials of the human condition.

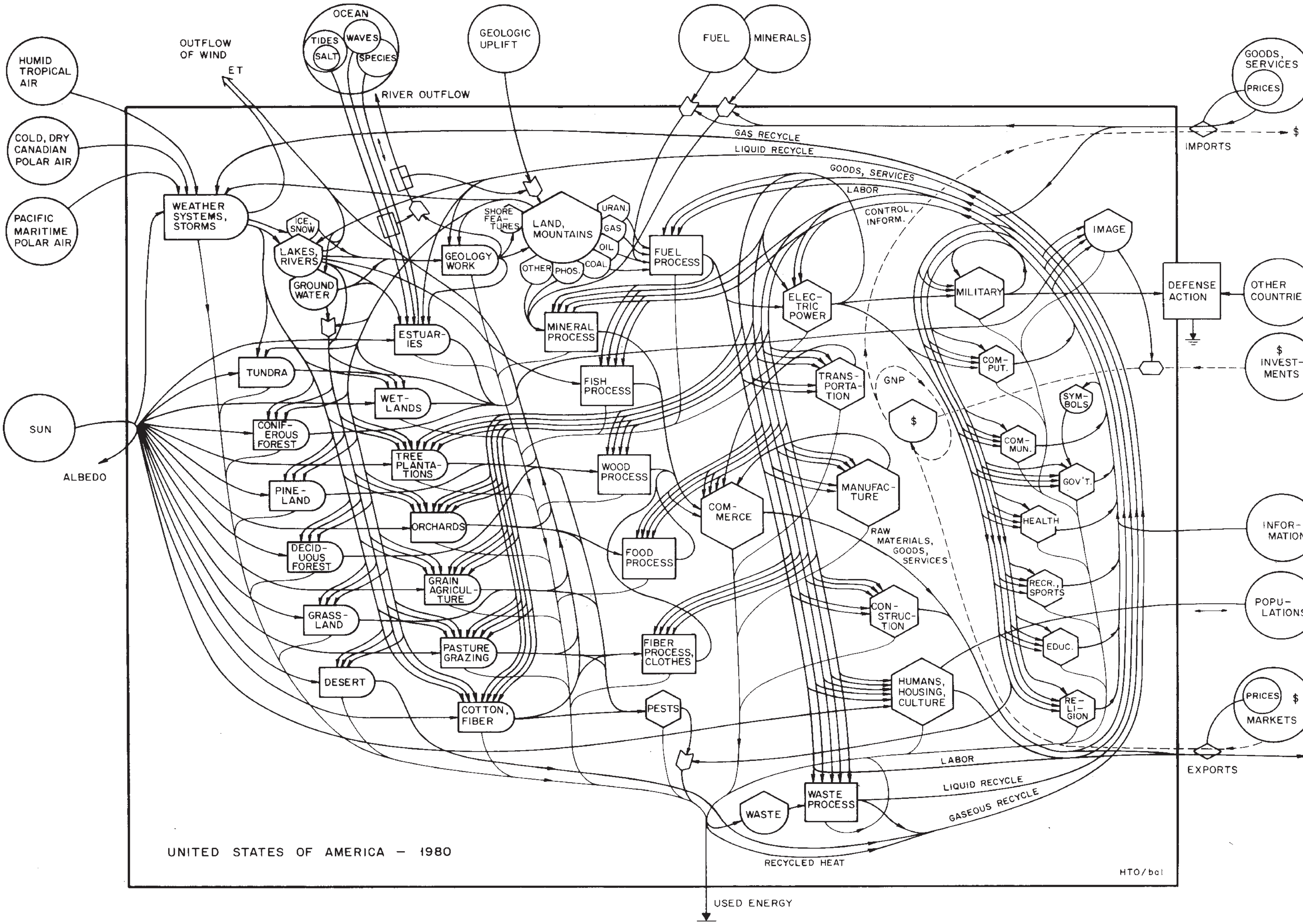
H. T. Odum's model (**Figure 1a**) abstractly delineates the actors in the system of interest, the relevant flow of energy, and depicts the concept of energy upgrading across the subsystems. Forrester (**Figure 1b**) is more successful at depicting the information network, the cumulative effect of flows and their informational triggers. Larkin's chart of the Christian spirit world (**Figure 1c**) is composed of highly abstracted (moral) relations and flows between supernaturals and humans in a metaphysical universe. Depicting a particular belief system at a particular time and place in history, this figure is a good diagrammatic example of the kind of informational systems that humans create and operate within. Robins' model (**Figure 1d**), inspired by the Church of the Subgenius, presents surreal graphic narrative, a postmodern belief system in perverse parallel to Larkin's Christian representation of the spiritual universe. Robins uses traditional and postmodern techniques, such as humor and confronting the strangeness of the familiar. This brings home the importance of creative imagination, human perversities and fictitious relationship in the formation and function of human ecosystems. Our position with regard to method-for-theory is that a synthetic understanding of human ecology must integrate the creative/imaginary/supernatural systems with those previously recognized as ecology *sensu stricto*.

[2] A paradigm is a worldview, belief system, series of assumptions, methods and techniques, and exemplars for problem solution held in common by a scientific community (cf. Khun 1970).

To help imagine that a synthesis of these diverse aspects of human ecology is possible, we offer Rappaport's (1971,1984) model of ritual regulation and ecosystem function among the Maring, a horticultural people of the New Guinea Highlands (**Figure 1e**). Here, complex relationships with a powerful spirit world are integrated in a holistic understanding of the supernatural belief system, community and inter-group social relations, and local subsistence activities. A human ecosystems theory premised on the methodological prescription of radical synthesis must begin where Rappaport left off. All relevant components of human ecology, i.e. physical, biological, social and cultural (including spiritual) must be integrated in the development of models that attempt to describe, and ultimately understand, human ecosystems.

Recommendation note for reading the rest of this essay

After perusing the six introductory system illuminations, you may wish to go directly to Section II, in which the prelude to human ecosystem theory is laid out. After skimming this section, you can go back to Section I: Method for Theory and entertain the document in its entirety.



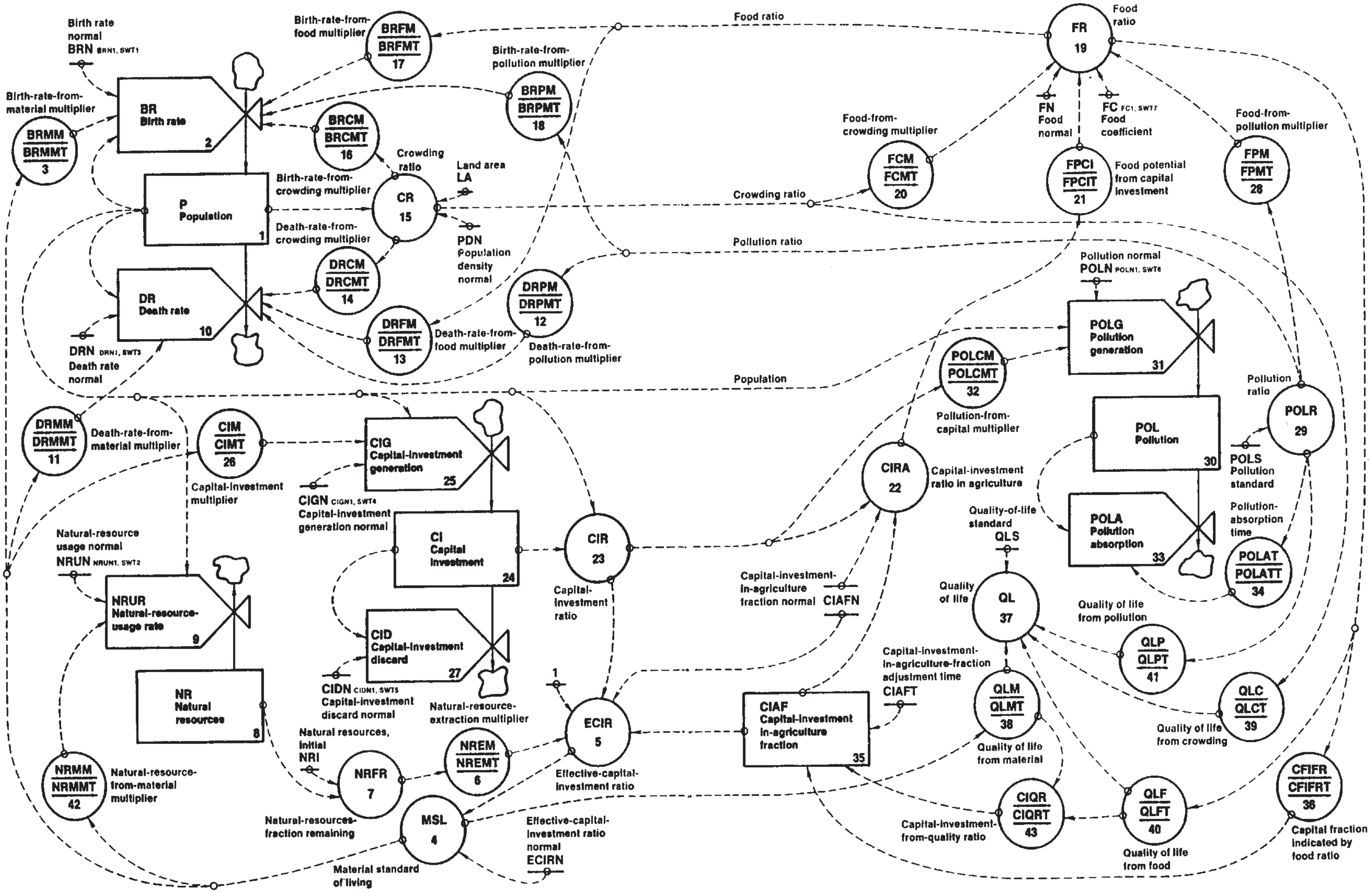
UNITED STATES OF AMERICA – 1980

Figure 1a. An Ecological Model of the Economy of the United States of America in 1980 (H.T. Odum 1983, Figure 23-17)[3].

The modeling conventions used here are based in part on thermodynamic principles: the conservation and entropy laws. The global heat sink at the bottom represents all the entropy losses. Circles represent sources of energy that serve to drive the system. Energy storage is depicted with a birdhouse-like icon. The bullet icon represents producers of energy (plants) from which energy flows to consumers, depicted by the hexagon. The arrowheads are flow interaction or control gates. Rectangular enclosures are used for miscellaneous subsystems and processes. There are two types of flows: 1) a straight line depicting energy flow, and 2) a dashed line with a $ sign depicting money flow.

There are five subsystems that are grouped together in staggered columns with the vertical groupings suggesting relationships between the components in each column. The first column (starting at the left) represents biomes. The second, ecosystems, with the vertical hierarchy based on degree of human manipulation (top less, bottom more). The third and fourth columns depict commerce: the third column shows processes that have some non-human energy inputs, while the fourth are fully industrial processes using fossil fuels. The last column represents a variety of human social sectors and institutions. Overall, the subsystems and their dominant flows are arranged left to right in order of increasing energy quality (increasing amounts of embodied energy).

[3]The original figure caption cites Odum and Odum 1980: Courtesy McGraw-Hill Book Company. However, this model does not appear in either the 1976 or 1981 edition of *Energy Basis for Man and Nature* (McGraw Hill). Apparently it first appears in *Systems Ecology* 1983, but therein H.T. Odum gives an erroneous citation.



Complete diagram of the world model interrelating the five level variables — population, natural resources, capital investment, capital-investment-in-agriculture fraction, and pollution.

Figure 1b. Human Global System Model (Forrester 1971, Fig.2.1).

This human ecosystem model, created under the auspices of the Club of Rome, focuses on five quantitative variables (accumulations within the system, depicted as rectangles): population; natural resources; capital investment; capital-investment-in-agriculture fraction; and pollution. These accumulations/variables are interrelated in dynamic ways. Specifically, the levels of the variables are caused to change by flows. Two types of flows are used here, information (the dashed line) and material flows (the solid line). (Forrester 1961 recognizes six types of flows.) Decision functions determine the rate of flows, in this case material flows. Decision functions act as valves, such as the one for birth rate in the upper left corner. Only information leads into a decision function. The very small circles are information take-offs, or branching points, of an information flow. The very small circles with the bar through them are information take-off parameters that act as (temporary) constants. The large circles are concepts that act as auxiliary information variables. They are concepts that have been separated from the decision functions because they have independent meaning, and significant influence controlling flows. The irregular cloud icons are sources or sinks for the material flows and lie outside the system as depicted. All of the closed loops are feedback loops. Some of them are "positive-feedback loops" that generate growth in the system. Other loops, the majority here, are goal seeking "negative-feedback loops" that move the system toward some objective (Forrester 1969).

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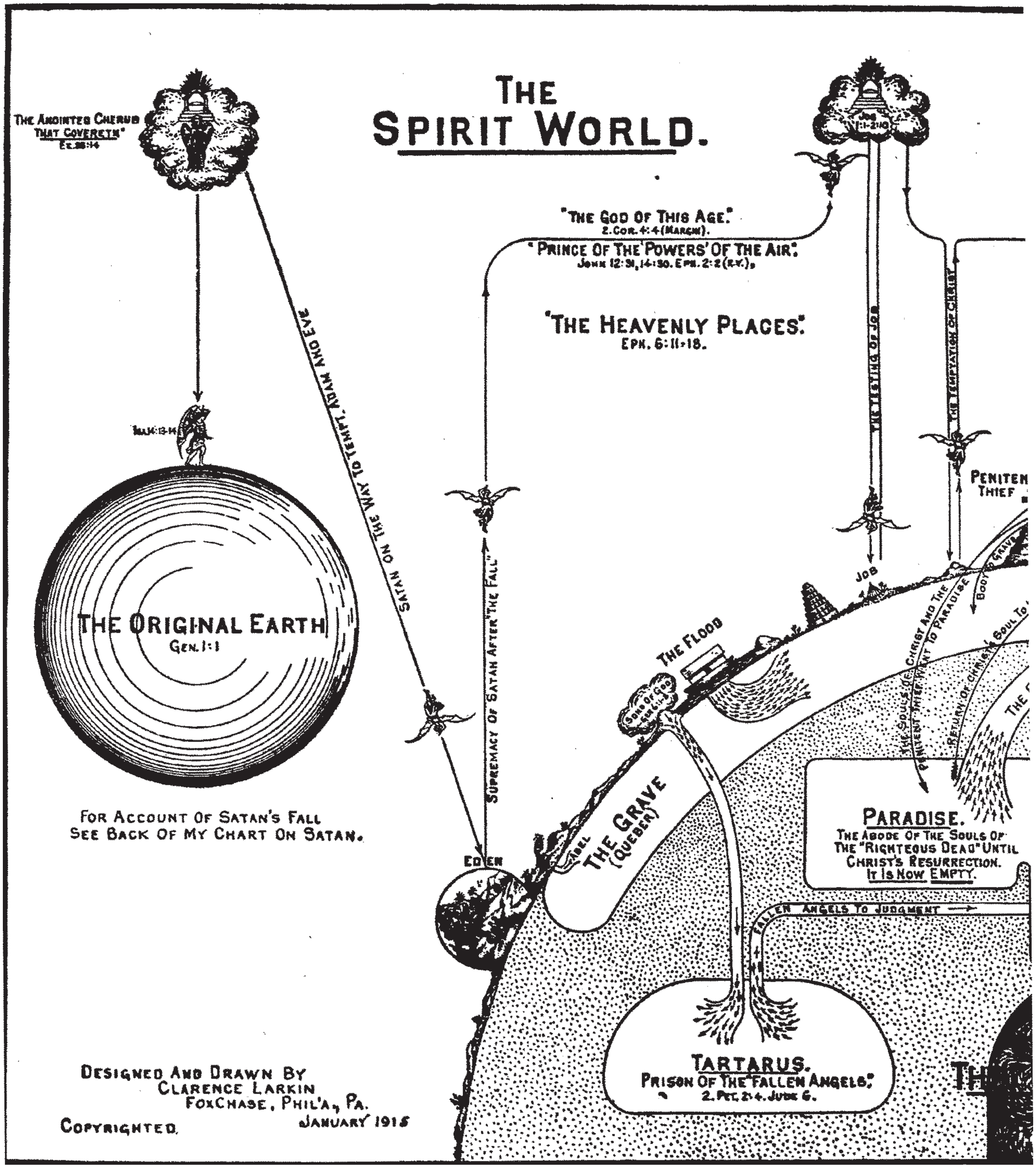
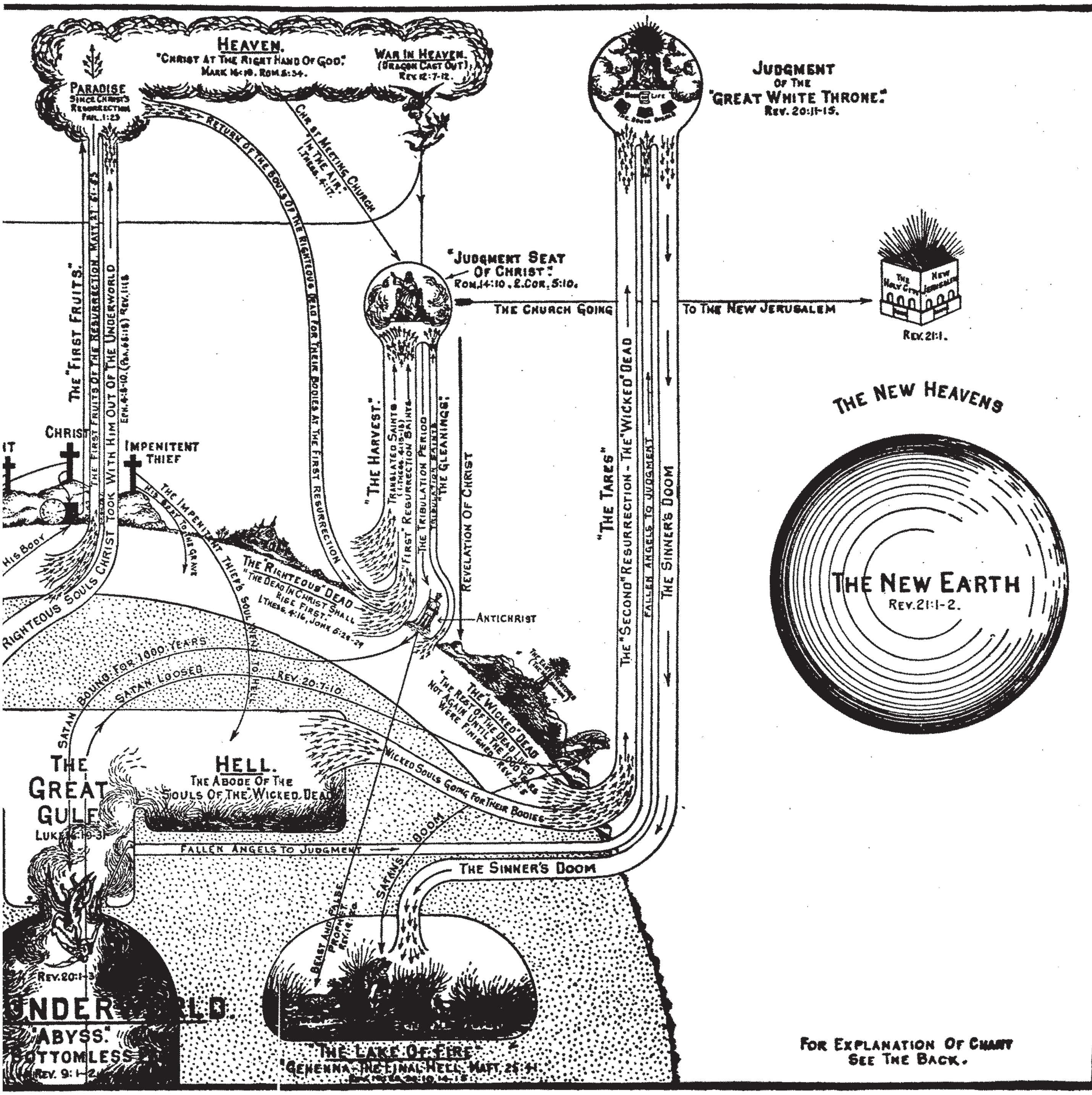


Figure 1c. The Spirit World: A Christian Belief System (Larkin 1920).
Originally designed as a wall chart for Clarence Larkin's Baptist ministry[4] in early 20th Century Pennsylvania, this graphic model displays the historico-spiritual (proscribed) evolution of humankind (from left to right) with special attention to differential pathways followed by human souls in their obligatory relationship to celestial spirits. This is a system regulated by the gates/switches of Divine Judgement (upper right corner), where souls are sorted into the 'Righteous' and the 'Wicked,' each with separate final destinations ('Heaven' and 'The Lake of Fire,' respectively). The Spirit World is an alternate universe that Christians gain access to in the after-life. In this system, final decisions are made by supreme beings; humans are regulated as flows of matter (reposited bodies that are redistrib-



uted at resurrection and judgement, upper right) and as energy (eternal souls) that unite upper panels ('The Heavenly Places') with the mundane (three Earths, Paradise and Hell). A fundamental dialectical tension is maintained between 'Righteous Spirits' (Christ, God, Pure Angels) and 'Wicked Spirits' (Satan and other Fallen Angels), while humans negotiate between the two.

[4]Larkin (1850-1924) was trained as a draftsman and was called to preach the Word of God later in life. He created at least 62 religious wall charts, relying heavily on his early training in the graphical representation of systemic functioning for expression and illumination of his religious beliefs.

Figure 1d. A Postmodern (After) Life
(Robins, in Stang 1994:89).

In this postmodern cosmos, the Spirit World is closer than one might think. Using irreverent satire, this figure depicts a hierarchical universe analogous to the Christian one in which 'elect' humans (those ordained by the Church of the Subgenius) gain access to 'Helle' and ever-ascendant supra-universes (the place you *really* want to end up in…) while other humans suffer in the abyss of 'Heaven.' Still essentially dualistic, hierarchical panels are disassembled into seeming chaotic morasses of gross humanity. Upon closer inspection, however, we find that distinct pathways do exist, such as the maze portals of 'false slack' that deposit unworthy souls into 'The Abyss'(middle left), and conversely, the escape vessels and transformative path that leads into 'Bob's' mouth (upper middle right). Reigning spirits of the upper panel are, principally, Bob Dobbs, and secondarily, the pantheons in Asgard and Valhalla. The lower panel is ruled by unseemly spirits including 'God,' some angels and various devilish creatures. Here, fueled by fear itself, humans are tortured with self-inflicted punishments—they can escape "if only they *would stop believing*…" (Stang 1994:88). Ultimately, however, the postmodern spirit guide ('the punchline') is the 'Pot o' Gold.' We are left with a somewhat ambivalent feeling: to what extent are we living the afterlife right now?


"Earth"
"God"
The ABYSS
The Vestibule
"HEAVEN"
The Sullen
The Gullible
The Indifferent
The Negligent
Talk Radio Commentators
Jazzercize Instructors
Anti-Porn Crusaders
Health Creeps
Cops
Self-righteous ex-smokers
Telemarketers
Accusers
GEHENNA
New Age-ers
Loveburgers
Rude Bus-drivers, Clerks, Floor-walkers & Petty Functionaries
The Namby-Pamby
Facile Optimists
The Lustless
Hollywood Movie Producers, Record Executives
The Trendy
Plagiarists
The Unoriginal
MTV Personalities
"Hip" Poseurs
Bobbies who borrow without repaying
Most Televangelists
Lawyers, Betrayers, Traitors to "Bob," False Subs, Pinkanucks, Child Molesters, Realtors, Rapists & Rip-off Artists

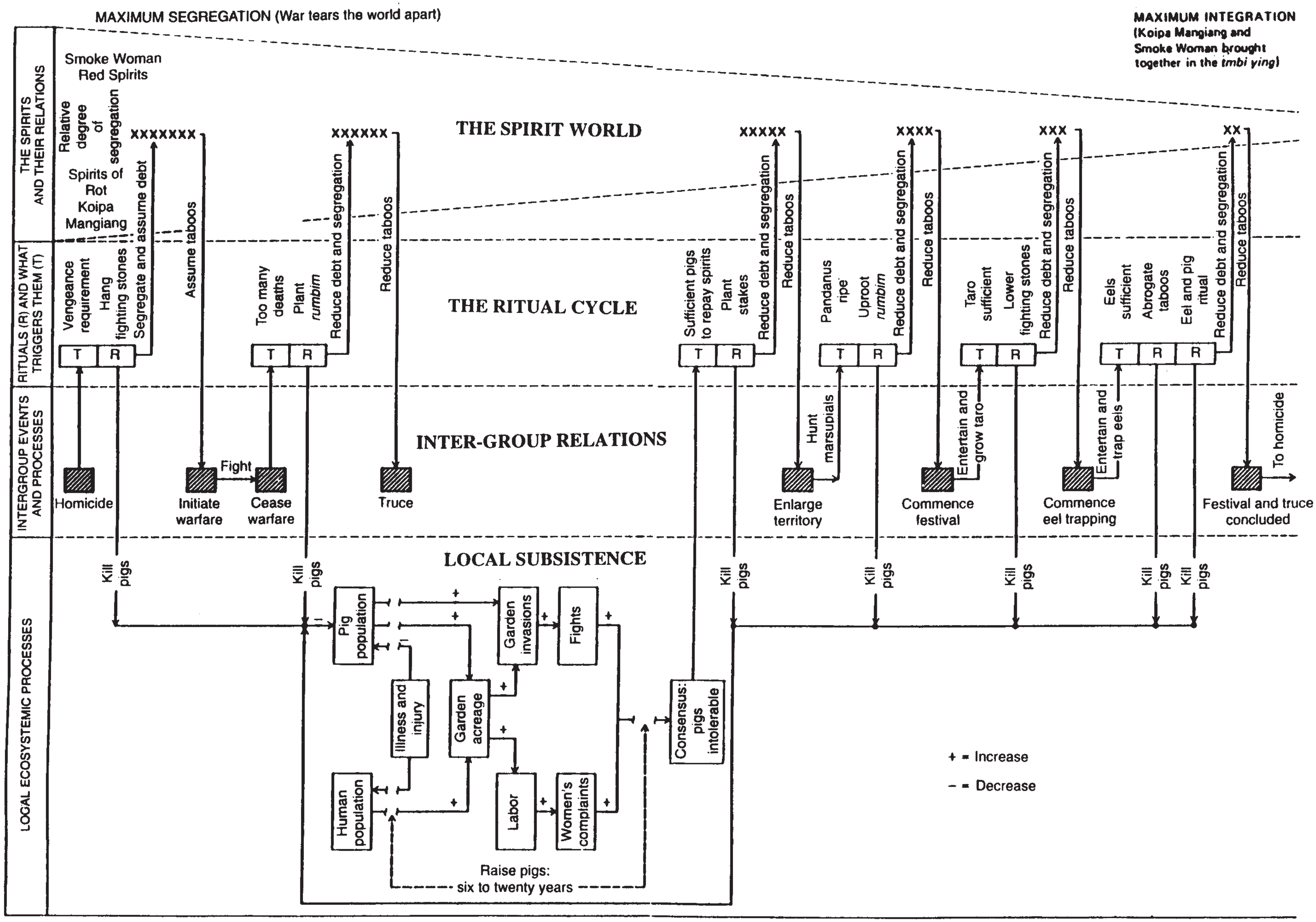

MAXIMUM SEGREGATION (War tears the world apart)
MAXIMUM INTEGRATION (Koipa Mangiang and Smoke Woman brought together in the *imbi ying*)
THE SPIRITS AND THEIR RELATIONS
RITUALS (R) AND WHAT TRIGGERS THEM (T)
INTERGROUP EVENTS AND PROCESSES
LOCAL ECOSYSTEMIC PROCESSES
THE SPIRIT WORLD
THE RITUAL CYCLE
INTER-GROUP RELATIONS
LOCAL SUBSISTENCE
Smoke Woman
Red Spirits
Relative degree of segregation
Spirits of Rot
Koipa Mangiang
xxxxxxx
xxxxxx
xxxxx
xxxx
xxx
xx
Vengeance requirement
Hang fighting stones
Segregate and assume debt
Assume taboos
Too many deaths
Plant *rumbim*
Reduce debt and segregation
Reduce taboos
Sufficient pigs to repay spirits
Plant stakes
Pandanus ripe
Uproot *rumbim*
Taro sufficient
Lower fighting stones
Eels sufficient
Abrogate taboos
Eel and pig ritual
T
R
Homicide
Initiate warfare
Fight
Cease warfare
Truce
Enlarge territory
Hunt marsupials
Commence festival
Entertain and grow taro
Commence eel trapping
Entertain and trap eels
Festival and truce concluded
To homicide
Kill pigs
Pig population
Human population
Illness and injury
Garden acreage
Garden invasions
Labor
Fights
Women's complaints
Consensus: pigs intolerable
Raise pigs: six to twenty years
+ = Increase
– = Decrease

Figure 1e. Ritual Regulation and Ecosystem Function among the Maring (Slightly modified from Rappaport 1971, 1984; reproduced with permission of the estate).

Rappaport's functional model of a Tsembaga Maring ecosystem is the first known diagrammatic attempt at integrating supernatural beliefs and cycles of ritual practice with 'local ecosystemic processes.' His depiction is of a cybernetic system in which beliefs and ritual practices regulate the relative abundance of pigs, social harmony and ultimately, human population. Rappaport separates system components into horizontal panels. Each panel portrays a domain that is a critical part of larger interrelations between the spirit world, the practiced ritual cycle, extra-community relations and biological constraints and affordances. In the top panel, 'The Spirit World,' Smoke Woman mediates between the living, the dead, and other influential spirits in the system, effectively guiding the Maring (through their shamans) in a proscribed but delicate cycle of segregation and integration. Red Spirits (strong, dry, hot) exist in dialectical opposition to the Spirits of Rot (fertile, moist, deathly). Both harbor members who were once living Maring and are involved in Maring affairs at various levels. The management of these complex spirit relationships is accomplished through the processes delineated in the middle two panels which in turn are intrinsically related to the bottom panel of local subsistence processes. In 'The Ritual Cycle' panel, a simplified outline of the Maring ritual cycle is given, showing the (supernatural) obligations incurred in daily living (triggers, 'T') and the rituals ('R') that satisfy them (taboo, pig sacrifice, planting of *rumbim*, etc.). The cycle starts over with the rituals that signify the end of a year-long festival, after which taboos are lifted and maximum integration is achieved both in the Spirit World and in the local social system. The next panel, 'Inter-Group Relations,' depicts social events such as inter-group homicide and warfare, truces and festivals. Throughout the ritual cycle, pigs are killed. This effectively regulates the local pig population (bottom panel, 'Local Subsistence'), which reduces garden invasions and labor obligations (primarily for women). This model can be seen as a benchmark in the move towards synthesis of the major components of human ecosystems. It integrates cybernetic systems principles with the humanistic and informational depictions of socio-cultural-spiritual systems.

SECTION I. METHOD FOR THEORY

This section is concerned with the structure and use of theory. Following Pickett, Kolasa and Jones (1994) we recognize the value of explicitly laying out methods[5] and conceptual constructs for building theory and promoting intellectual integration. This effort relies on a long history of development in the philosophy of science that we will not do justice to here, as our goal is to provide only a brief overview of the nature of theory, motivations for its development, taxonomy, anatomy, ontogeny, and some of the environmental contexts in which it is found. Together, these constitute method-for-theory.[6] This framework will then be used to sketch the raw beginnings of an integrative theory of human ecosystems in Section II.

A. THE NATURE OF THEORY

In addition to the plausible benefits of increasing precision in conceptualization and clarity in communication, sensitivity to the structure of theory offers some less tangible rewards. Among the rationales for sensitivity to theory, Pickett, Kolasa and Jones (1994:58) point out that theory "[h]elps you make decisions about what to do next in a world in which 'everything is a little bit interesting' but only some things are worthwhile," and also, "[p]revents you from getting lost in the threatening tide of details."

Sensitivity to the nature of theory also puts dichotomous and fragmented debates into perspective (see **Figure 2**), since exclusionary tendencies often develop out of protracted dichotomous debate. Examples from our intellectual heritage include the irritating nature/culture debate (for discussion see Scoones 1999:486); and the old Cartesian mind-body separation problem. Gaps in understanding widen as polar positions become entrenched. Discontinuity and fragmented understandings may become ends in themselves, perpetuating closed intellectual environments. Nonetheless, dichotomous debate can be resolved through integration, ultimately leading to more holistic understandings.

Theoretical Progress Via Integration

An initial simplified working definition of integration is the amalgamation of existing theory, perspectives, approaches, models or data that are apparently disparate. Although a desirable goal, achieving integration is not easy. Some of the procedures and circumstances necessary for successful integration include: (1) *Specifying Domain*. For integration to happen, the focus or domain of the relevant theories/subdisciplines, which are the subjects of integration, must be clearly stated. With clearly defined subject matter and boundaries, the development of linkages between the theories becomes more feasible. (2) *Conceptual Clarification*. The domain is not the only component of theory that needs to be clearly delineated. There is usually confusion about the meanings and subjects of specific concepts within a theory. Clarification of concepts also enables the asking of new questions that may further integration and the development of theory. (3) *Consideration of Scale and Level*. Integration requires consideration of the scale(s) at which a theory operates. Theories may answer questions across levels of organization, particularly adjacent levels of a particular scale, as in **Figure 3a** (bottom part) or **Table 1**.

Studies within ecology *sensu lato* can be ordered on several axes to illustrate the diversity of research areas within this arena (Likens 1992). **Figure 3a** represents the subdisciplines of bioecology[7] ordered along an axis of abiotic to biotic foci (Likens 1992; Pickett, Kolasa and Jones 1994).

[5] 'Methods,' as used here, refers to principles of inquiry. 'Techniques' refers to crafted procedures and proficient artisanal skills. The focus of this essay is on methods.

[6] Method-for-theory refers to the process of understanding what theory is, how it is constructed and how it is used to achieve goals of understanding and explanation.

[7] Here, bioecology refers to what is more conventionally simply called 'ecology,' to facilitate use of the term ecology (*sensu lato*) for the domain that includes both biophysical ecology and sociocultural ecology.

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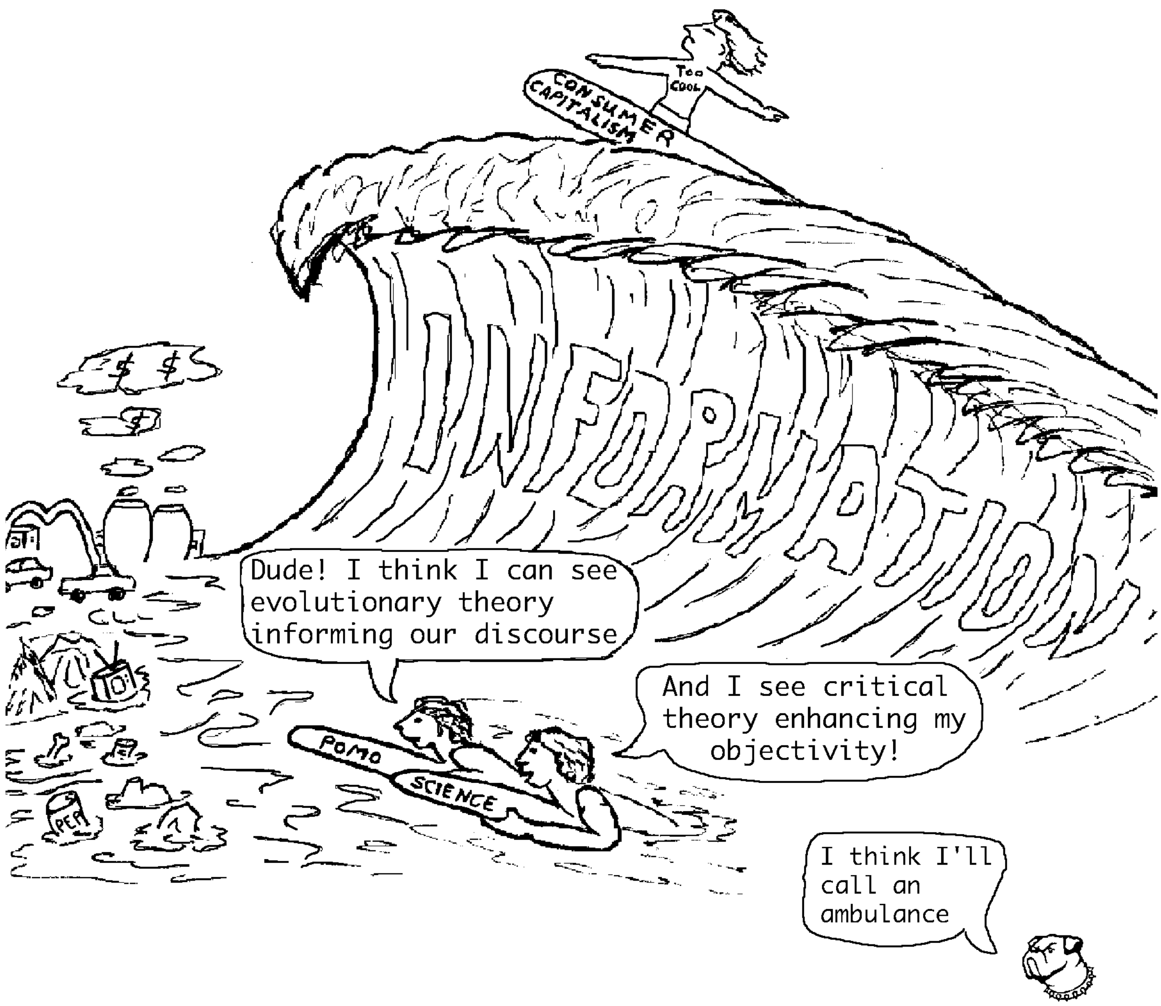


FIGURE 2. RIDING THE WAVE (Georgia Journal of Ecological Anthropology 1999:91).
The postmodern consumer capitalist environment as a final commentary on the relevance of dichotomous and fragmented contemporary discourse. Humor, because it is an innate mechanism for dealing with cognitive dissonance, can raise representational states to higher levels of complexity. In this case anthropological debate is situated within the impending doom of a runaway revolution in information technology. Here the felt need for a more holistic understanding or overarching theory is created by the reader's eye view.

The diverse discipline of human ecology can also be schematically depicted along axes of organization. As such, **Figure 3b** includes some of the subdisciplines and subject matter that contribute to human ecology. This contributing subject matter is ordered: (1) horizontally within multiple categories of environment (physical, biological, cultural, and social); and (2) vertically along a hierarchical scale of organization (individual to population to world systems). The diversity of the contributing subject matter illustrates the daunting challenge presented to those interested in achieving integration within human ecology.

Understanding and Explanation

Understanding is experience made intelligible by applying concepts and categories to apprehending the general relations between particulars. Scientific understanding is an 'objectively' determined match between some set of confirmable, observable phenomena in the non-human and human world(s) and a conceptual construct. Some of the components of this type of understanding can be seen in **Figure 4**. Our take on the components reflects a philosophy of human sciences that draws heavily on the humanities.

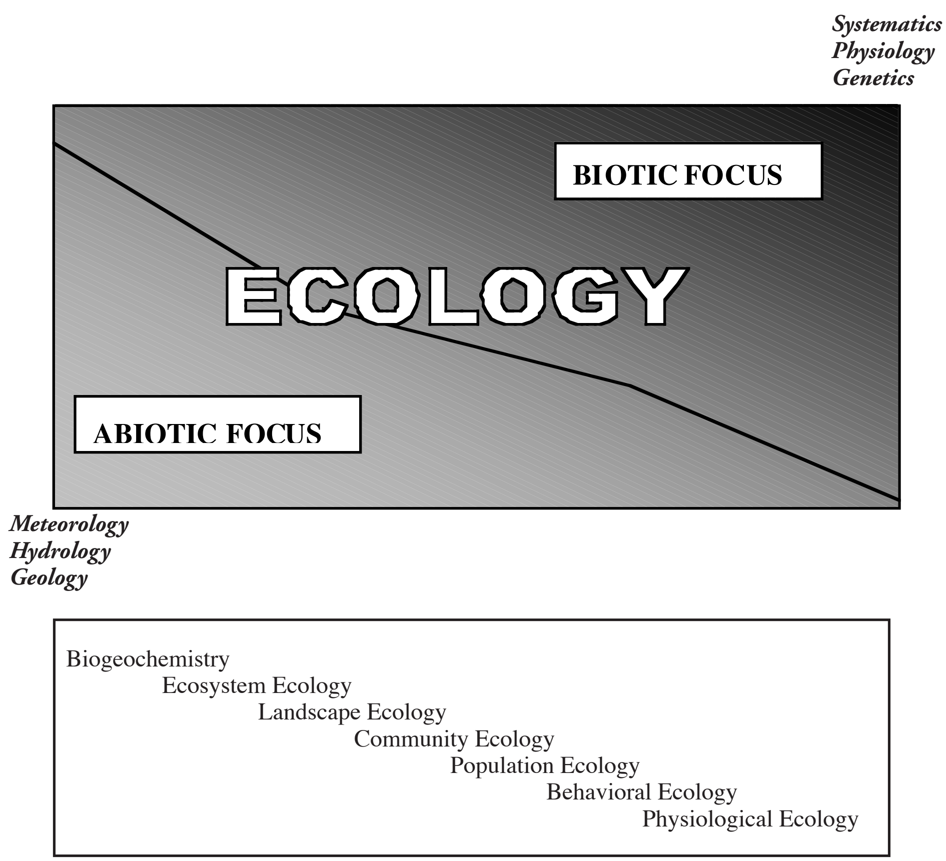


FIGURE 3A. SPECTRUM OF ECOLOGICAL SUBDISCIPLINES (Modified from Likens 1992).
The field of ecology, in the broadest sense, incorporates a variety of studies ranging from those that focus on abiotic relationships to those that focus on biotic relationships. The bottom part of the figure depicts one of many possible dimensional axes for topic areas and subdisciplines in biological ecology.

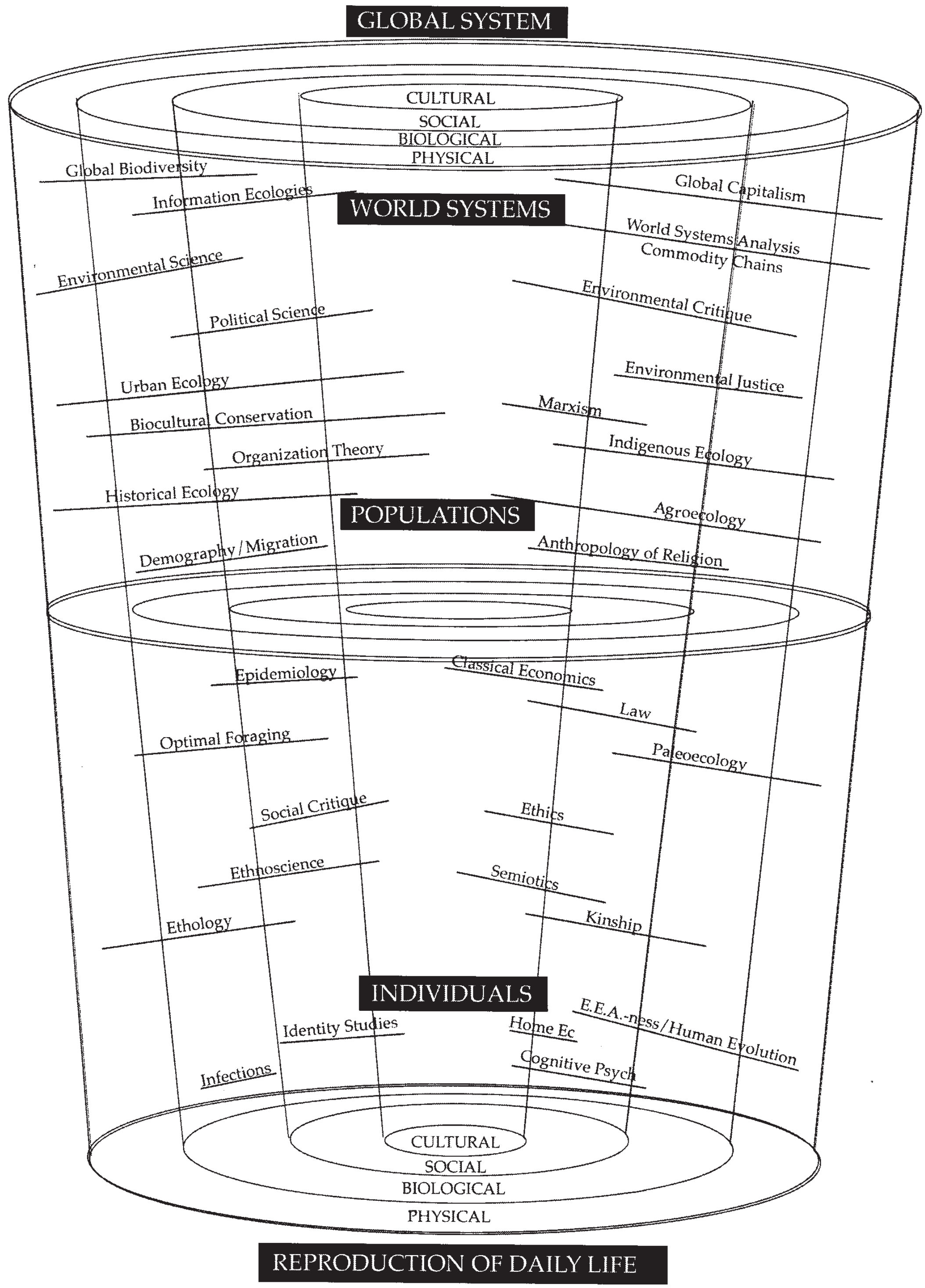


FIGURE 3B. HIERARCHY OF HUMAN ECOLOGY WITH CONTRIBUTING TOPIC AREAS AND SUBDISCIPLINES. Human ecology is a broad field. Contributing topic areas and subdisciplines can be ordered along two axes. The first (horizontal) axis illustrates the four environments (physical, biological, social, and cultural) in which subdisciplines focus their studies. Not all contributors operate in all four environments. The second (vertical) axis illustrates the scale of organization at which the subdisciplines and subject matter tend to operate. The multiple environments exist in a vertical hierarchy of organization, from the individual (reproduction of daily life) at the lowest level on up to the population, and ultimately to the highest level, the global world system. We have located some subfields relevant to human ecology in a hierarchy across the scope of multiple environments. This is by no means an exhaustive accounting of possible subfields.

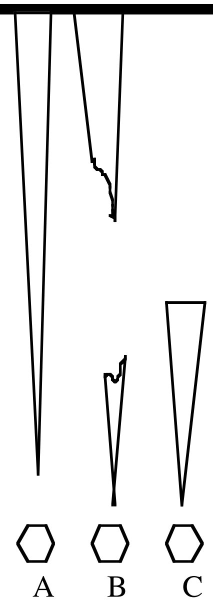
The relationship between understanding and explanation is that explanation is the process of relating conceptual constructs to observable phenomena, and understanding is the professed and hoped for result of this process. Explanation may (among other things): (1) relate phenomena (patterns) to causal mechanisms; (2) resolve phenomena into processes at lower hierarchical levels (Pattee 1973); and (3) contextualize phenomena within larger processes.

B. MOTIVATING THEORY: FUNDAMENTAL QUESTIONS AND RADICAL SYNTHESIS

Fundamental Questions

"Fundamental questions are the most effective tools for advancing understanding because they address any one of five ways to improve theory" (Pickett, Kolasa and Jones 1994:113). Specifically, fundamental questions can lead to: (1) establishment of

TABLE 1. HIERARCHY OF HUMAN ECOLOGICAL LEVELS.

ECOLOGICAL LEVEL	*SCOPE AND DOMAIN*[8]	*SOME COMPONENTS/ PRINCIPLES*	*INTELLECTUAL AWARENESS to date*
WORLD SYSTEMS **Global** **Subregional**	 	Components include global synoptic processes down to local systems	Dominated by fragmented logics
POPULATION **Cities** **Communities** **Demes** **Family/Household**		Components are populations in local systems	Analysis of aggregates Demographic bias
INDIVIDUAL **Socially Interacting** **Socially Isolated**		Components include physiological processes (harmonics) in the individual as a system with input and output environments	Consensus/ Optimality EEAness (Environments of Evolutionary Adaptedness) Individuals as agents

[8] Dual Significations: two interpretations of the depicted scope and domain are possible. The first is the possible scope of an individual's world, represented by three examples (A,B,C hexagons): (A) a jet-setter with big business or NGO connections; (B) the president of one of the big-five nations; (C) a local community leader. The second interpretation is that the three hexagons depict possible theoretical domains or (dis)continua across human ecological levels: (A) full spanning of all levels; (B) ruptured understanding; (C) restricted scope of analysis.

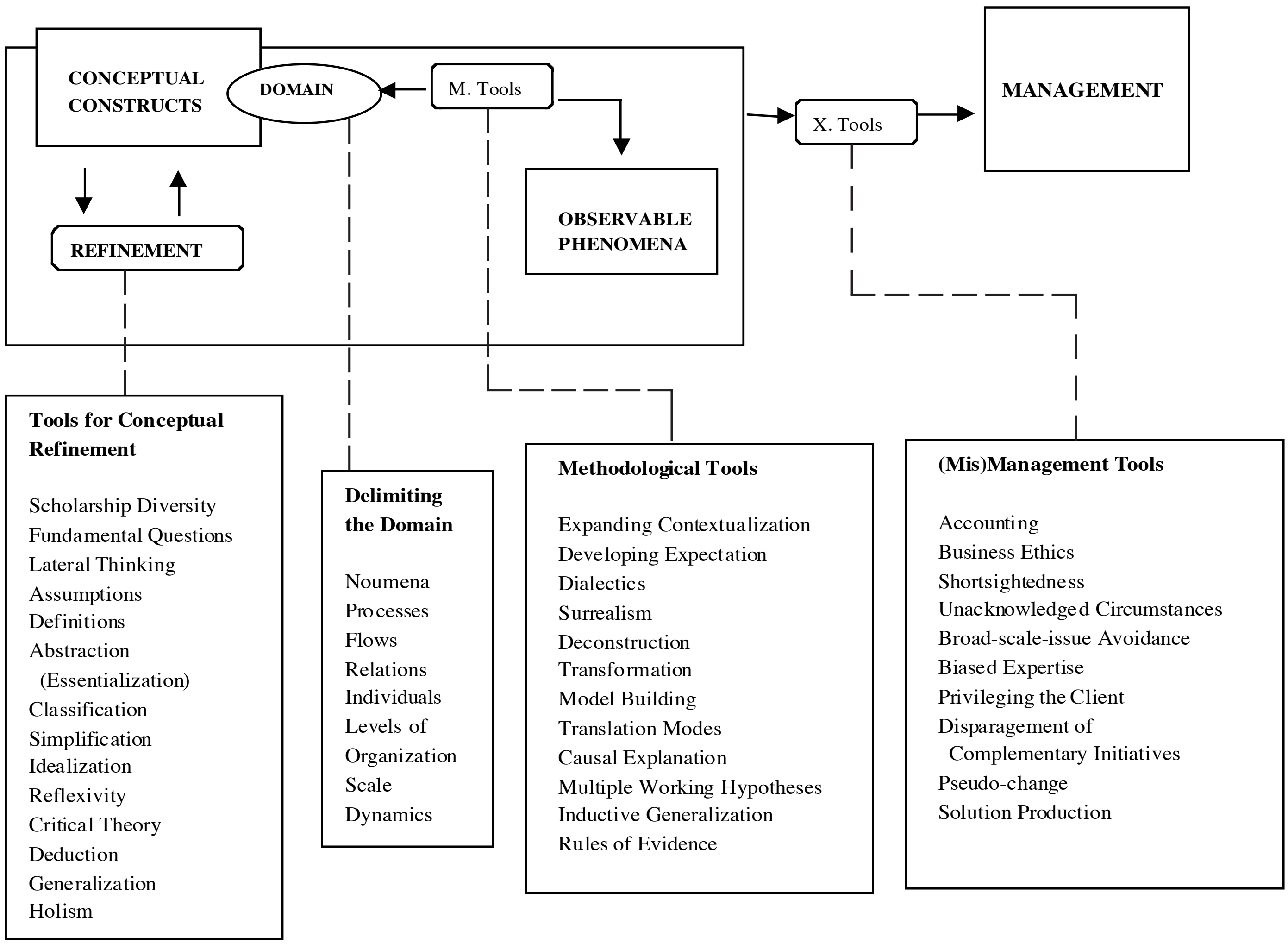


FIGURE 4. COMPONENTS OF SCIENTIFIC UNDERSTANDING (Adapted from Pickett, Kolasa and Jones 1994, Fig.2).

This model represents a way of parsing out some of the responsibilities of a method for building theory. Conceptual constructs are continually refined through two processes. The first involves internal refinement through the use of several conceptual tools. The second results from (re)specification of the domain, particularly the definition of relationships between different conceptual constructs. Delimiting the domain requires that attention be paid to scope, scale and process, but it also requires the employment of methodological tools for relating the domain to observable phenomena. Typically, science is caricatured as doing this through hypothesis testing (via rules for evidence), causal explanation and model building. Understanding in the field of human ecology requires additional methodological tools for teasing out complexity. Typically external to theory building, applied human ecology requires management tools to relate the 'real world' to the theoretical framework. These tools are often critiqued for their inability to achieve goals. That this is the case indicates a lack of development of these tools by the practitioners of management, resulting in part from an emphasis on territoriality, immediate gain, advertising, and obfuscation of assumptions.

theory or missing theoretical components; (2) refinement of theoretical components; (3) rejection of inadequate theory or inadequate theoretical components; (4) replacement of a theory or some of its components; and (5) increasing the scope of theory.

Figure 5 shows a number of types of questions that may not be mutually exclusive, but that do have different motivations and foci. Among these, fundamental questions are those aimed at changing/advancing the structure or content of understanding. Their loci for action are usually the conceptual constructs or the lines of interaction between theory and observable phenomena (**Figure 6**). Limits to current understanding invite ongoing efforts to identify and address fundamental questions as a crucial part of theory building.

Formulating fundamental questions can also facilitate change in understanding by clarifying the scope of inquiry. Tinbergen's (1963) four questions are an attempt to acknowledge different ways of answering the question 'Why?' in biology. These questions can be summarized as: (1) functional (questions about the adaptiveness of behavior); (2) proximate (questions about the mechanisms of behavior); (3) ontogenetic (questions about how behavior changes through development of an organism); (4) phylogenetic (questions about the ways behavior changes as species evolve). By distinguishing between these fundamental types of questions and the distinct answers they generate, Tinbergen helped bring theoretical clarity to otherwise sterile debates about which is the correct response to any given 'Why' question.

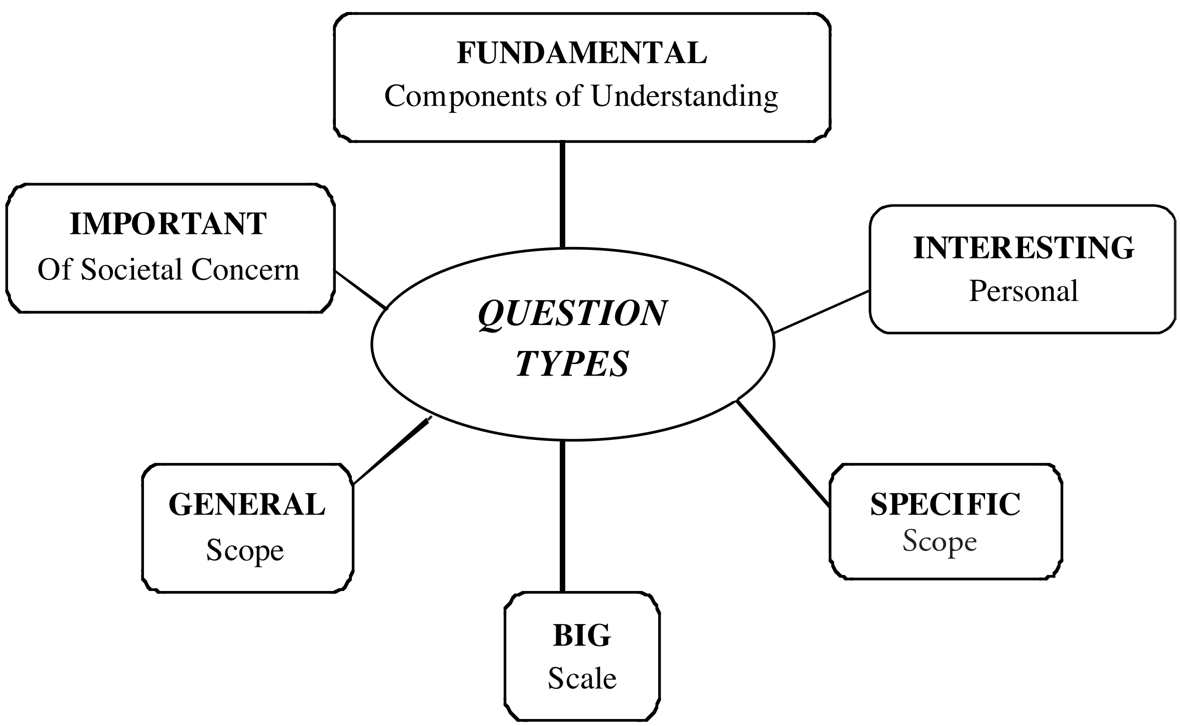


FIGURE 5. TYPES OF QUESTIONS (From Pickett, Kolasa and Jones 1994, Figure 6.2. Reproduced with permission of publisher).
Fundamental questions are concerned with the components of understanding within a field of science. "Big" questions are broad scale. The labels "general" or "specific" refer to the size of the conceptual scope or inclusiveness of the domain addressed. Important questions are those of societal interest, whereas interesting questions are motivated by personal fascination. These types of question are not mutually exclusive.

"In case several fundamental questions are competing for attention, they may be ranked according to their logical precedence, clarity, and potential to unify" (Pickett, Kolasa and Jones 1994:113). Fundamental questions should be prioritized to the extent that they are interesting, feasible, fulfill logical requirements already present in theory, establish sound and clear concepts (Novak and Gowin 1984), as well as definitions and interactions, while encompassing a broad scope so as to advance generality (Kuhn 1977, Mayr 1982, Slobodkin 1985). Even if such questions are privileged they may lead to incorrect theory, but in the process greater clarity of concepts, hypotheses and tests may be achieved.

Fundamental questions should tend, by definition, to new theories.[9] While keeping the scope of the inquiry in mind, fundamental questions ask about observed patterns of phenomena and possible explanatory processes/mechanisms. In this endeavor, judgement, reason and previously accepted ideas must be temporarily suspended so as not to constrain the person or group who seek alternative explanations (see **Appendix** for more on the possibilities of team thinking). Alternative explanations also come from within theory by unreasonably performing an extreme application of the building blocks of theory (generalization, idealization, abstraction, hierarchical integration), individually or in combination with others.

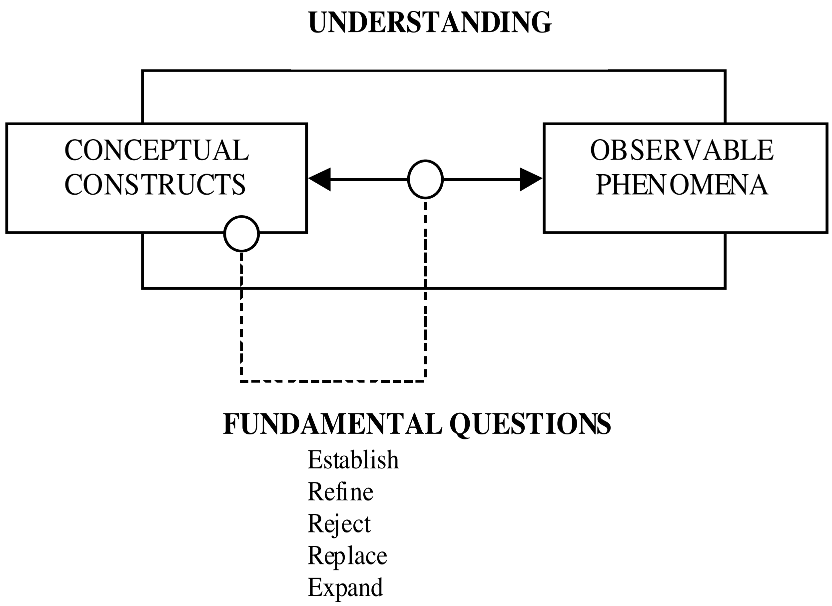


Figure 6. The Relationship Of Fundamental Questions To Understanding (From Pickett, Kolasa & Jones 1994, Fig. 6.1. Reproduced with permission of publisher).
Fundamental questions can change understanding in one or more of five ways by which they affect theory: by establishing new theory; refining existing theory or components of existing theory; rejecting theory or components of theory; replacing flawed theory or components; and expanding existing domains of theory.

[9] Where do radically new theories come from? See the Green Hat, Appendix.

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Integration and Synthesis

Theoretical understanding changes through the integration of disparate paradigms. This is the option of radical synthesis. Specifying the disparate paradigms and identifying possible fundamental questions to guide cross-paradigm integration helps to articulate an idea toward which integration can aspire.

Two general ways of synthesizing disparate areas of understanding are additive and extractive integration. In the first, two or more complete theories are connected, perhaps ultimately merged, through the implications of asking a very broad scale question. The paradox of additive integration is that the product may be more than the sum of its parts (**Figure 7a**). In extractive integration, selected components of different theories are recontextualized to provide new building blocks and relations. Here the result is expected to be synergistic (**Figure 7b**).

C. TAXONOMY OF THEORY

A taxonomy of theory must reflect differences among the goals or objectives, the structure, and the foci of domains of different kinds of theories, and hence, their modes of understanding. As a result of differences in objectives, structure and domain, theories can be classified along at least the four axes of temporality, phenomenology, abstraction and generality (see **Table 2**). But, because theories are complex systems, a single theory can have components that span different classes. The four axes are not mutually exclusive.

Temporality

Theoretical understandings differ in their emphasis on the degree and kinds of causality attributed to prior states vs. current relationships. The term 'contingency' allows the understanding that current relationships and constraints have accumulated from past interactions.

TABLE 2. KINDS OF THEORY (Modified from Pickett, Kolasa and Jones 1994, Table 5.1).

Classes	*Dichotomous Characters*	
Instantaneous Vs. Long term	*Ahistorical*	*Historical*
	Still Life	*Evolutionary*
Phenomenological vs. Mechanistic	*Dynamic (emergent)*	*Static (design)*
	Existentialistic	*Mechanical*
	Dialectical	*Nondialectical*
Abstract[10] vs. Literal	*Axiomatic*	*Nonaxiomatic*
	Formal	*Factual*
	Normative	*Descriptive*
	Hypothetical	*Empirical*
	Postulative	*Constructive*
General[10] vs. Specific	*Universal*	*Local*
	Strategic	*Tactical*

[10] Continua rather than strict dichotomies.

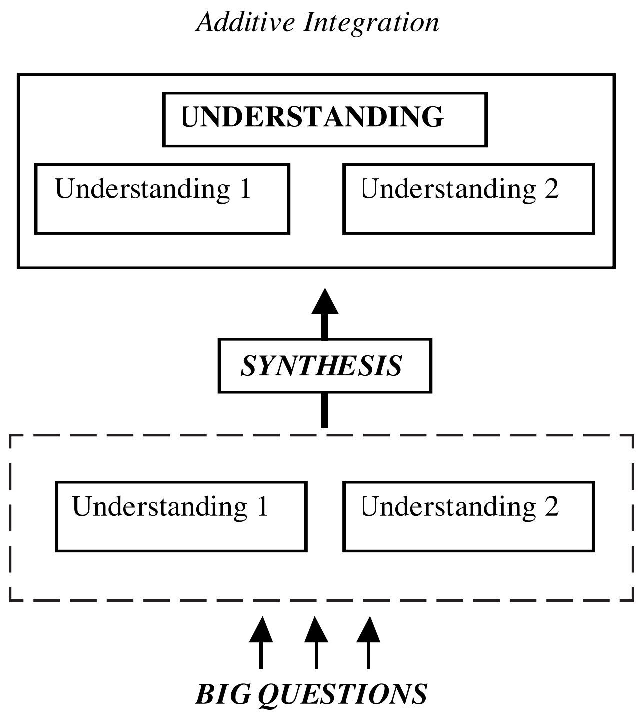

Figure 7a. Additive Integration (From Pickett, Kolasa & Jones 1994, Fig. 7.1. Reproduced with permission of publisher).
Two or more relatively complete areas of understanding can be linked or amalgamated in their entirety to produce new theoretical understanding. This synthesis is additive integration. The impetus for such integration often comes from general or "big" questions.

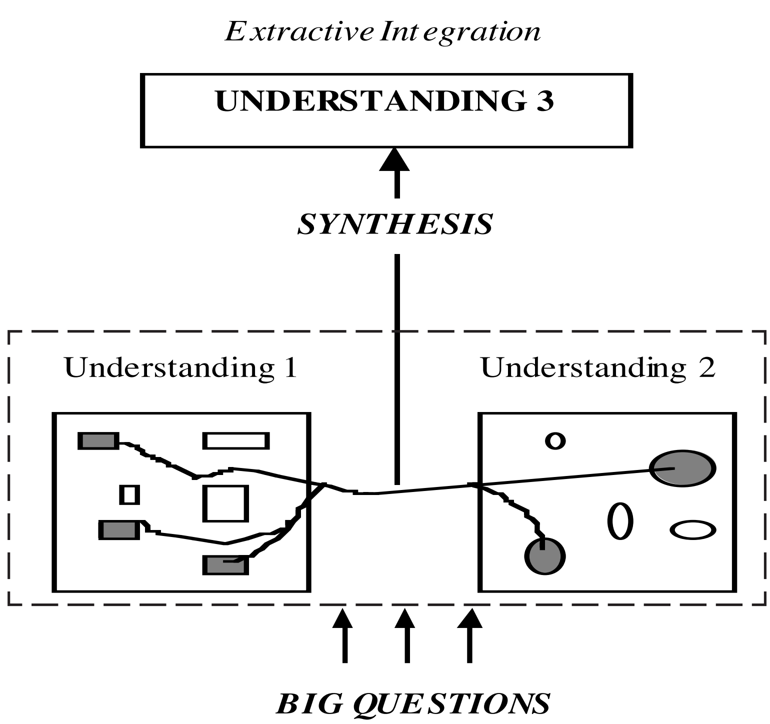

Figure 7b. Extractive Integration (From Pickett, Kolasa & Jones 1994, Fig. 7.2. Reproduced with permission of publisher).
Select parts of existing theories may be extracted and synthesized to formulate new, integrated understanding. Extractive integration is often motivated by general or "big" questions.

Phenomenology
Theories may conceptualize phenomena as being caused by dynamic interactions (phenomenology) which are not reducible to components at lower levels, or as being caused by underlying mechanisms. Hierarchical nesting usually allows us to ignore typical contradictions between these two extremes (Pattee 1973).

Abstraction
Models may range from highly specific space-time contexts to abstract, ideal (including unreal) systems.

Generality
Theories unlinked by nesting or hierarchy to other theory may maximize only two of the following three parameters: generality, precision, realism (Levins 1966). The degree of generality or specificity of a theory depends on the extent to which both precision and realism are being employed. If both are considered important, generality will be minimal.

D. ANATOMY OF THEORY
Anatomy refers to the structure of theory, how it is delimited and the components out of which it is constructed. An overview of the variety of the components of theory is presented in **Box 1**.

Basic Conceptual Components of Theory

Notions
Notions are informal beginnings. They are often provided by imagination, intuition, analogy and metaphor, and can provide material for the development of theory. From the creative side come the juxtapositions, psychotic brainstorms and insights upon which methodological tools may be brought to bear such that conceptual constructs are created and domains constructed. If something is intuitively plausible, then it is likely a notion, as mature theory is often counterintuitive.

Assumptions
Assumptions include postulates, boundary conditions, facts from other theories, and logical rela-

Box 1. Components of Theory (Modified from Pickett, Kolasa and Jones 1994, Box 3.2).

Basic Conceptual Devices
- Assumptions—conditions or axioms needed to build theory
- Definitions—conventions and prescriptions necessary for the theory to work with clarity
- Concepts—abstract ideas generalized from regularities in phenomena, or conceived through reflection and imagination

Empirical Content
- Facts—confirmable records of phenomena, checked and re-checked across time
- Confirmed Generalizations—condensations and abstractions from a body of facts that have been checked and re-checked

Derived Conceptual Devices
- Hypotheses—testable statements derived from or representing various components of theory
- Models—conceptual constructs that represent or simplify the world or subject matter of concern
- Theorems—ideas or propositions deduced or proposed as demonstrable deductions

Framework and Structure
- Framework—nested causal or logical structure of a theory
- Domain—the scope in space, time and phenomena addressed by a theory
- Translation modes—procedures and concepts needed to move from the abstractions of a theory to the specifics of application or test

tionships between facts. Assumptions are statements about the nature of a domain. These axioms are required before theory can be built. At the start of systematic inquiry, guesswork is often required to choose among seemingly unlimited alternative assumptions. Poorly developed theory can result from leaving assumptions implicit rather than making them explicit. Illumination of implicit or background assumptions can be quite revealing. Longino (1990) discusses the case in which the same body of evidence is said to support conflicting hypotheses or theories, depending upon the investigator's world view or background beliefs and assumptions.

Definitions

Definitions express the essential nature of things. They help specify and convey meanings in definite, clear and determining ways. Among the things that must be defined in a theory are the basic objects and relationships that are the subject matter of that theory.

Concepts

Concepts are generalizations or abstractions of regularities, patterns, and imagined possibilities. They can refer to individuals, phenomena or relationships (Leary 1985) that are explicit enough to be evaluated.

Empirical Content of Theory

Observations

We distinguish between the observations that we make when we are awake and those we make when we are asleep and dreaming. Those observations that we treat as matters-of-fact are open to re-evaluation, their status as facts depend significantly on the ongoing process of renewed observation, or in the case of unique events, checking and contextualizing the record.

Accepted Facts

In human systems the acceptance of facts depends at least in part upon the conceptual environment. Some propositions and the evidence that they are facts may not be accepted, while other propositions with very little or no supporting evidence may be treated as facts. Contrasting viewpoints and critical examination of underlying assumptions are two of the procedures used in the consensual establishment of facts.

Confirmed Generalizations

The abstraction of accumulated records of facts can result in confirmed generalizations. This inductive activity allows a group of observations or facts to become a basic building block for theory, providing material for hypotheses, models and theorems. Contingent on the qualities of the facts, confirmed generalizations are given more credence as supporting evidence accumulates.

Derived Conceptual Components of Theory

Hypotheses

Hypotheses relate conceptual constructs to observable phenomena. They are tentative assumptions and explanations that help formalize expectations and provide grounds for action.

Models

Models are externalized simplified conceptual or mental iconic representations of a system or process, put forward as a basis for theoretical or empirical understanding. Generally they depict some of the overall structure of the system, and those information causality pathways and materials/energy flows that result in the symptoms of interest.

Theorems

Theorems are derived constructs, deduced from assumptions, definitions, basic concepts or the axiomatic structure of models and theories.

Theory Framework and Structure: Theory as System

Framework

A theoretical framework unites all components of theory in a coherent conceptual structure (**Figure 8**). Relationships between conceptual devices are laid out, including the relations between back-

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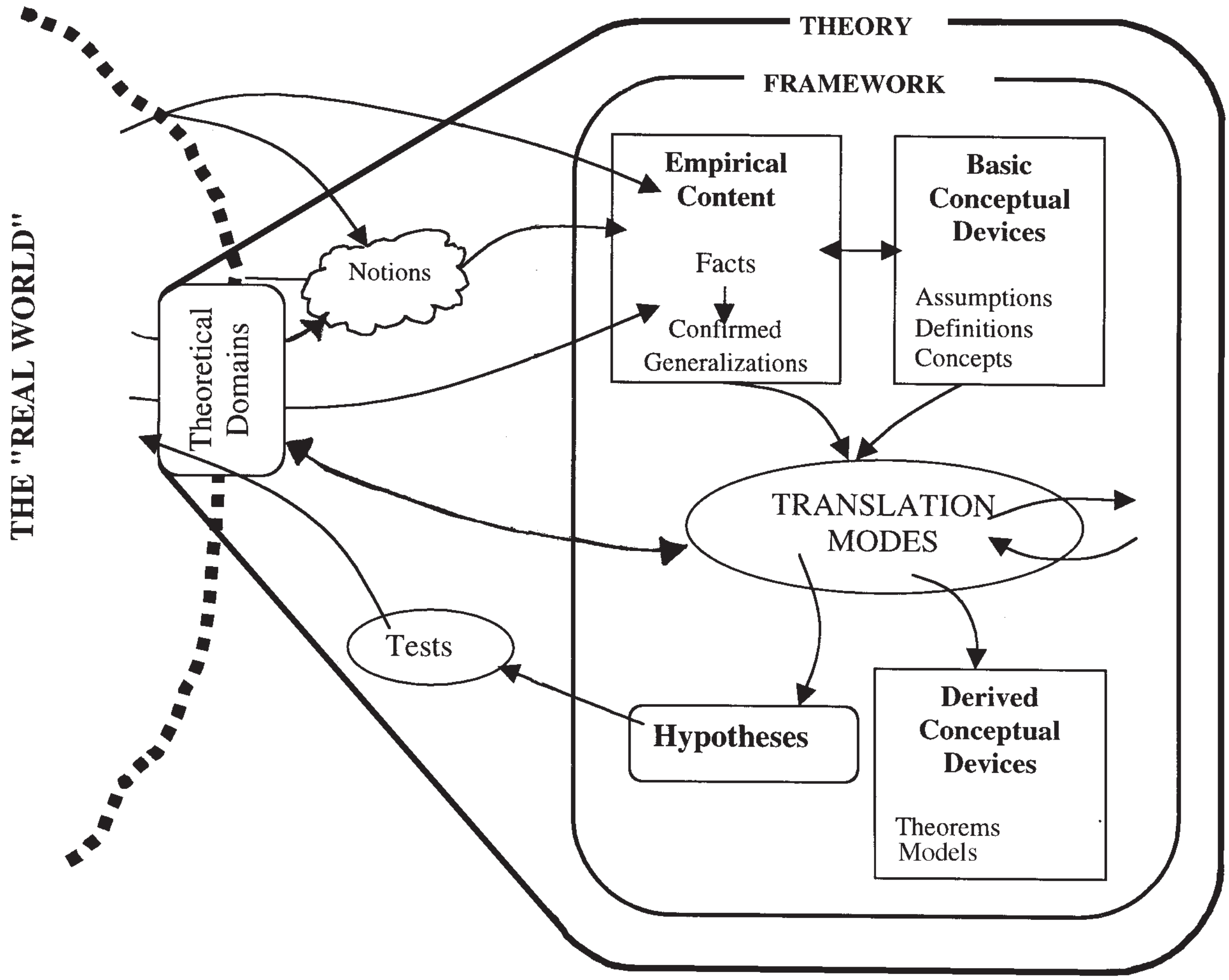

Figure 8. Relationships Between Components of Theory.
This figure illustrates the relationships between the various components of theory (see **Box 1**). The domain is the spatial and temporal scope that a theory addresses, while the framework of a theory provides the logical structure. Observations of the 'real world' (from both within and without the theory's domain) contribute to notions and facts about that world. In time, facts can become confirmed generalizations. These empirical components inform basic conceptual devices (assumptions, definitions and concepts). Translation modes relate the empirical content and basic conceptual devices to more derived conceptual devices (hypotheses, models and theorems). Translation modes also relate empirical content and the basic and derived conceptual devices to the real world phenomena that the theory addresses through tests of proposed hypotheses. Additionally, translation modes relate the empirical content, conceptual devices, and results of tested hypotheses to the structure of the theory, allowing for revisions and clarification of the theory's domain and framework.

ground assumptions, theoretical constraints and the conceptual inputs and outputs for theoretical models. Frameworks change as theories mature.

Hierarchy
The several potential domains of inquiry of a theory should be related explicitly to each other in a meaningful way. Typically, this occurs by creating a hierarchical organization of (sub)theories varying by scale in time, space and organization. As such, domains are often covered by subtheories, which may be used for different jobs (Pattee 1973) and confer different levels of generality.

Domain
Domains delimit the scope in space, time and level of organization of "a class of phenomena assumed (by theory) to share certain properties and be of a distinct and general type" (Hirschfeld and Gelman 1994:21). The domains of an inquiry should be explicit and specific, as much as possible, though they may be expanded or restricted as theory develops. Domains typically become more and more restricted as theory develops, because refinement shows that the theory is not as grandly applicable as originally presumed.

As mentioned above (under hierarchy), domains may lend themselves to different levels of generality depending on their breadth or their scope. Particularly important for designating a domain are the relevant phenomena, concepts, and scales (time, space, organization). Conceptual constructs in a subtheory domain need not apply to the broader theoretical domain nor to other subtheories, but the importance of determining whether or not they do apply cannot be overstated.

Translation Modes
Translation modes facilitate the conceptual transposition of abstract ideas, generalizations and models to specific domains and on-the-ground applications in experimental or field situations, and back again.

Openness
To maintain a dialogue between abstract or idealized domains and observable phenomena for testing and theory revision, a framework requires translation modes. The space that the translation modes fill is inherently open. Openness in theoretical systems of understanding also is noted where observable phenomena are renamed as facts or confirmed generalizations, inside theoretical frameworks. Openness of theory does not preclude the importance of axiomatic deduction in the development of theory.

E. ONTOGENY OF THEORY

The utility of a theory depends upon its ontogenetic state, or degree of maturation, at a particular point in time. Content and structure can change along three axes: completeness, development and integration (**Box 2**). Completeness refers to the inclusion of items on the roster of theory compo-

Box 2. Three Axes of Theory Change (Modified from Pickett, Kolasa and Jones 1994, Box 4.1).

Completeness—the different components of theory listed in Box 1 have different jobs to play in a theory: More complete theories, i.e., those with more of the components, can do more of the jobs required, e.g. abstract, simplify, generalize, explain, and predict, than those that are less complete

Development—well-developed theory has more clearly derived conceptual constructs, more explicit conceptually and empirically rich components, more thoroughly worked out and refined components

Integration—in more mature theory, the connections among the components are better articulated; dependency and unification are more explicit, with most of the components in place and related to each other within a framework specifying structure of the theory as a whole

nents in **Box 1**, keeping in mind that components can be added. Development refers to the refinement of components; they should be better worked out over time. Integration is indicated by increasingly well articulated connections among the components.

Why Theory Change is Important

"Failure to recognize how theory changes or indeed, that theory changes at all can be an impediment to furthering… understanding and integration" (Pickett, Kolasa and Jones 1994:86). Immature theories lack components and integrating links. An immature theory may be prematurely rejected or entirely ignored when it is subjected to an over-designed test or heavily negative (non-constructive) criticism at an early developmental stage.

Ontogeny and Testing

Early in its development, a theory might not allow appropriate tests of its validity. Without a specified framework, tests may encourage or discourage further development, but are quite meaningless. Even with a clear framework, strong theories can fail to predict behavior. At this point, intervening variables should be tested before throwing the baby out with the bath water. This process is a continual integration of related constructs, theories and paradigms, beholden to logical empirical consistency.

Scope And Refutation

Broad-scoped, well-developed theories are less easily refuted by only a few failures, since other variables and theories may be integrated to save the theory. Finer scale theories may be refuted by fewer cases of failure, due to fewer possible intervening processes, and less possibility of subdivision.

Conceptual Refinements

Conceptual constructs may be refined as a result of expansion of observable phenomena (externally), or logical or conceptual changes (internally). Application of theory requires an awareness of the ontogenetic status and development of the conceptual constructs.

How Theories Change: Theory Assembly, Development, Maturity

As theory develops, it becomes more and more complete, by the addition and refinement of theoretical notions, constructs, derived constructs, and structure. **Figure 9** shows both increase in the number and refinement of components as theory matures. At first the emphasis is on the addition of components. By the consolidating stage of theory development all of the components are in place. Subsequently, refinement of components is what is emphasized. The refinement of components marks a second stage in the development of theory.

Box 3. Stages to Theory Maturity (Based on Pickett, Kolasa and Jones 1994, Box 4.1 and Figure 4.1).

Pre-theoretic—represented by rudimentary development of a few components

Intuitive—simple and fundamental components present, including definitions, concepts, and models

Consolidating—derived conceptual devices begin to mature

Empirical-Interactive—with concepts, definitions, and domain increasingly clarified, hypotheses are more amenable to evaluation

Confirmed or Rejected—judgement by the community of the adequacy of evaluation and strength of those outcomes for a mature theory; confirmed theories often permit practical application

The stages of maturation shown in **Figure 9** and summarized in **Box 3** can be thought of as an idealized developmental sequence. Theory change is actually often haphazard, reflecting an amalgam of different empirical pursuits and different subtheories, and in some instances more complex or highly derived components arise before simpler ones. Drawing on other theories for components may also result in transfer problems, where those components acquire different meanings and interpretations in their new context. Nonetheless, the key idea is that the jobs a theory is able to do depend upon its stage of maturity, i.e. the richness of its roster of theoretical components and their refinement.

As a theory begins to take shape and to be used it often becomes clear that existing components must be replaced or refined. Theory may emerge from pre-theoretic notions by adding components, without showing much refinement. At the consolidating stage basic conceptual components are refined, empirical content is refined and expanded, derived conceptual components are added and refined, and the theoretical framework and structure begin to become apparent. Measures of component refinement include exactitude, empirical certainty, applicability and derivativeness.

DEGREE OF DEVELOPMENT →

DEGREE OF COMPLETENESS ↓

	Component / **Status**	**Pre-theoretic**	**Intuitive**	**Consolidating**	**Empirical-Interactive**	**Confirmed or Rejected**
Basic Conceptual Devices	***Notions***	/////	/////	/////	/////	///////////
	Assumptions	/////	//////	/////////	/////////	///////////
	Definitions		/////	//////	/////////	///////////
	Concepts		/////	//////	/////////	///////////
Empirical Content	***Facts***	/////	/////	//////	/////////	///////////
	Confirmed Generalizations			/////	//////	///////////
Derived Conceptual Devices	***Hypotheses***	/////	/////	//////	/////////	///////////
	Models		/////	//////	/////////	///////////
	Theorems			/////	//////	///////////
Framework and Structure	***Framework***			/////	/////	///////////
	Domain	/////	/////	//////	///////	///////////
	Translation Modes			/////	//////	///////////

FIGURE 9. COMPLETENESS AND DEVELOPMENT OF THEORY (Modified from Pickett, Kolasa and Jones 1994, Figure 4.1). See Box 1 for a description of the components. Degree of hatching denotes increased refinement and precision in theory development.

Exactitude

Exactitude reflects the explicitness of the components of theory, how clearly assumptions are stated, the completeness of the stated domain, and the specificity and manner of presentation of the derived conceptual components. Clarity of terminology is a key aspect of exactitude. Because words can sometimes have more than one meaning (for example a word's common versus its scientific usage) confusion regarding terminology often occurs. One should therefore clearly and explicitly state the meanings of terminology that are critical to a theory. Imprecise words usually mean muddled thoughts. If you are unable to state what you mean explicitly, then the odds are good that you do not really have a firm grasp on what it is that you are trying to say. Perhaps you are dealing with the ineffable.

Empirical Certainty

Empirical certainty reflects the degree to which facts and empirical generalizations are confirmed and evaluated, as well as the manner in which this is done.

Applicability

Applicability centers largely on translation modes. The applicability of a theory refers to how well the derived conceptual components are applied to observable phenomena. The translation modes help to link derived and empirical components.

Derivativeness

Derivativeness requires that the individual components and their relationships be analyzed. Here analysis refers to the working out of the implications of the components. Just as a theory develops via a dialog between the theory and the world it is designed to provide an understanding of, theories also develop through a dialog between the components of theory. This dialog will come from analysis of theoretical components and the refinement of theoretical concepts. Clarification of the components of a theory usually leads to the revision of the relationships between components. Internal consistency is a hallmark of mature theory.

In mature theories, components are well developed, well integrated and provide completeness (see **Box 2**). Complete theories have well-defined basic conceptual constructs and derived conceptual devices, as well as well-delineated domains, with internal structure and empirical content, allowing the development of hypotheses that can be confirmed or rejected. Confirmed mature theory has developed through prior phases of pre-theory, intuition, consolidation and empirical-interaction (see **Box 3**). Such theories come to represent the particular historical time periods within which they have developed.

Methodological Tools in the Development of Theory

A number of the methodological tools available to develop and refine conceptual constructs are listed in **Figure 4**. Diversity of scholarship is directly related to the diversity in the backgrounds and personalities of the investigators, as discussed below under the environments of theory. The role of fundamental questions was discussed at the beginning of this section. Lateral thinking is a form of educable creative intelligence presented most clearly by de Bono (1990a). It is particularly useful when coupled with the methodological skill of volitionally shifting one's mode of thinking, the most well known examples being those in de Bono's (1990b) six-thinking-hats idiom (**Appendix**). But this methodological skill, so ably promoted by de Bono, is useful within *all* of the 'tool' boxes in **Figure 4**.

Development of the Practice and the Practitioner: A Note on Skill Acquisition and Techniques

Though this essay is primarily concerned with methods in the development of theory, a note on some prerequisites for utilizing the methods is pertinent. Several important points can be made. (1) Group effort and diverse collaboration is essential. Mead (1964:265-266) discusses the central role of small 'clusters' of interacting individuals in the evolution of ideas and the importance of "…creating the conditions in which the appropriately gifted can actually make a contribution…" rather than

searching out and relying upon individual leaders. De Bono's (1990b) thinking hats technique (see **Appendix**) can improve group communication dynamics and productivity. (2) Creativity, imagination and lateral thinking should be encouraged. (3) Taboos or prejudices about proper communication modes should be discarded if it is in the interest of furthering theory. For example, the narrative form is poorly suited to describing networks of interactions in ecosystems. Graphical representations have multiple advantages (see **Table 3**). Foremost among these is the skilled reader's ability to see a nearly simultaneous analytic and synthetic understanding of the system portrayed. Though descriptive diagrams/ illuminations are not traditional forms of communication in most schools of

TABLE 3. SOME PRINCIPLES OF CONCEPTION AND REPRESENTATION IN GRAPHICS (From Stepp 1999:49).[11]

Principles	**Explanatory Notes**
1) Memory:	
–short-term memory unloaded	Short-term memory limitations are bypassed to the advantage of processing
–long-term memory enhanced	Long-term memory is shifted from rote to gist
–signs are more memorable	Memorability is enhanced through iconography, i.e., graphical "figures of speech" (e.g., metonymy), plus key words and phrases
2) Externalized Problem Solving:	
–allows ease of manipulation	Constructed externalizations, particularly icons, invite imaginative manipulations
–guides reader/viewer interpretation	Externalization plays a key role in completing any cognitive task
–near simultaneously analytic and synthetic	Takes advantage of high-speed visual capabilities for resolving and interpreting complex relationships
3) Semiotic Structure:	
–simultaneously layered	Concurrent elements at the sublexical, lexical and grammatical levels; co-occurrence and multilayering are the pervasive structural principles
–hierarchical (graphical) vs. linear (text)	Flexibility of levels of entry into graphics, as well as flexibility in directional processing
–transparency	Pellucidity enhanced through simultaneous views, topography, perspective and apparent movement
–emergent properties	Graphical formulations (including higher maths) are complex constructs whose implications their creators only partially anticipate; their unpredicted properties lie well beyond the scope of narrative, closer to the heart of lateral thinking (de Bono 1990a)
4) Graphic Literacy Skills:	
–input and output competence	Consumer-producer competence can be graded from knowledge, to know-how, to skill
–rights as reader, rights as creator	The implicit contract is that both reader/viewer and creator/producer will continually upgrade their levelsof comprehension and expression

[11] Sources: Brainerd and Reyna (1990), Hutchins (1995), Johnson (1987), Lock and Peters (1996), Scaife and Rogers (1996), Winn (1993), Zarger (1998), Zhang and Norman (1994).

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anthropology their use is recommended because of the heuristic advantages they confer. This means that practitioners are held responsible for developing their skill in reading and communicating in new, possibly unconventional modes.Other examples are humor, cartoons, and satire.

F. THEORY AND ITS ENVIRONMENTS

Constraint and Objectivity in Ecological Integration

To pursue radical integration and to bring together disparate paradigms, it is necessary to determine how paradigms, theories, and theoretical practices themselves constrain integration, and how those constraints may be overcome.

Two sources of constraints inject bias into the Academy: 1) bias that originates in society at large; and 2) bias that operates within the intellectual community. These constraints (often in the form of hidden assumptions) act as filters and control gates that influence intellectual thought and exchange. Within the Academy there are three additional overlapping kinds of sociological constraints on integration: 1) scholasticism, 'schools' of training, lineages that share approach, subject matter, publication outlets, and desired rewards; 2) methodological philosophy, including experimental vs. comparative, search for a single cause vs. evaluate spectra, hierarchical vs. single level, broad vs. specific methodologies; and 3) personality of individual researchers, with biases toward criticism vs. construction, quantification vs. qualitative analysis, creative expression vs. technical, practical vs. conceptual, and so on.

Different ontogenetic stages (explicitness), different currencies, and degree of difference between the objects being integrated all are potential constraints on the integration of concepts with phenomena, theory with theory, paradigm with paradigm, or hierarchical integration of any of these.

Investigative Objectivity and Changes in Paradigm

Objectivity has two immediate sources. One resides in the open-ended procedures that are applied to relating theoretical constructs to observable phenomena (**Figure** 4). Multifaceted methodological tools, including rules of evidence, deconstruction, and multiple working hypotheses, act as cross-checks, help to specify limits to knowledge, and contextualize biases. Such procedures encourage the individual to take a more distanced view, particularizing their accomplishments within evolutionary, historical, and cross-cultural perspectives. It may be recognized that no one's theory is able to explain certain sets of observable phenomena. On the other hand, when two or more theories are apparently accurate, coherent, and fruitful, it may be possible to combine them into a new paradigm. The second immediate source of objectivity resides in the diversity of the investigative community (Longino 1990). Reduction of bias is enhanced by the participation of investigators with different intellectual proclivities and cultural backgrounds. This is important, for example, in identifying previously understated, unstated, or unsuspected background assumptions. This kind of analysis may be critical for the open scrutiny of social biases, for recognizing the construction of power relations in dominant discourses, and for shifting paradigms in new and creative ways.

The next section of this essay represents an attempt to mobilize the kind of method-for-theory we have summarized above in the service of furthering integration and theory building in human ecology, particularly as it applies to human ecosystems.

SECTION II. TOWARDS A THEORY OF HUMAN ECOSYSTEMS

Section II uses the method-for-theory outlined in Section I to attempt to begin construction of a theory of human ecosystems. The rationale for seeking integration and synthesis is explored first, and some of the motivating questions are identified. Then, following the anatomy of theory outlined in Section I, we systematically go through some of the components that we have identified as starting points for the development of a theory of human ecosystems. This is a preliminary effort to bring together relevant pieces of disparate research and ideas to show the value of having a clear grasp of the methodology behind the development of theory, and to promote holistic thinking among students of human ecology. Further work is obviously necessary before a coherent working theory of human ecosystems can be developed.

A. INTEGRATION AND SYNTHESIS IN HUMAN ECOLOGY

Our motivation for promoting synthesis in human ecology is premised on the recognition that information flow is as central to understanding human systems as matter and energy flows. Our premise is that a truly *human* ecology should be responsible for the integration of both sociocultural ecology (traditionally the domain of the humanities) and biophysical ecology (traditionally dominated by the so-called 'natural sciences'). The history of human ecology's disciplinary development has led to increasing division of labor and fragmentation of knowledge, often delimiting potential know-how and restricting the scope of skill acquisition. This has sometimes resulted in such specialized worldviews that practitioners can not share common vocabularies or conceptualizations (for example, the anthropology department at Stanford University dividing into two departments: cultural and social anthropology vs. anthropological 'sciences'). On the other hand, the focus resulting from specialization within human ecology has resulted in considerable refinement of knowledge within each restricted domain. The discipline as a whole, then, appears in need of synthetic integration.

There have been several calls for just such an effort in human ecology. Redman, Grove and Kuby (n.d.) state that "[a]lthough it is not novel to recognize the interconnectedness of humans and the[ir] environment[s] (cf. Marsh 1864; Thomas 1956), constructing a new approach emphasizing an integrative framework equipped with comprehensive models, reinforcing methods, and complementary data is a growing and urgent priority." Scoones (1999) reviews the potential cross-fertilization of social science and ecological thinking, identifying several research topics in social science that actively use the principles of dynamic equilibrium, spatial and temporal variation, complexity and uncertainty, including historical ecology, 'structuration' or contextual/interactionist perspectives, and complexity in socio-ecological systems. Our own view, that a truly holistic approach to understanding human ecosystems must recognize and investigate the central role of *information,* was articulated almost thirty years ago by Flannery (1972:400):

> Up until now, it has mainly been the humanists who have studied the informational aspects of complex societies—art, religion, ritual, writing systems, and so on. The 'ecologists' have largely contented themselves with studying exchanges of matter and energy...humanists must cease thinking that ecology 'dehumanizes' history, and ecologists must cease to regard art, religion, and ideology as mere 'epiphenomena' without causal significance. In an ecosystem approach to the analysis of human societies, everything which transmits information is within the province of ecology.

Go back to the Introduction to this essay and look at **Figures 1a**, **b**, **c**, **d** and **e** again. Keep our goal of integrating biophysical and sociocultural ecology in mind as you read the following proposed framework for a theory of human ecosystems.

Radical Synthesis

A partially nested hierarchy of paradigms relevant to human ecology can be seen in **Box 4**. What would be the nature of potential integration across these contrasting paradigms?

For example, population and ecosystem paradigms historically represent two apparently opposed approaches within bioecology (**Box 5**). These paradigms can also be applied to ecological anthropology (**Figure 10**). A recognition that populations function as parts of ecosystems is a potential point of integration. The ecosystem is the most inclusive ecological conceptualization at any given level in the ecohierarchy. But because it is holistic, it is also difficult to achieve conceptually. Conceptual stumbling blocks include the prevalence of diffuse causality, indeterminism and the difficulties of bounding variables and systems.

In addition to being part of natural ecosystems (*sensu lato*), humans also define themselves by their worldviews (± praxis) as part of constructed world systems. This results in a hierarchy of hu-

Box 4. Partial Nesting of Some Paradigms Relevant to Human Ecology and Some of Their Key Characteristics (Concept based on Pickett, Kolasa and Jones 1994, Box 7.1).

Academic Paradigms relevant to the study of ecosystems
- Holism
- Evolution
- Historical Process (*La Longue Durée*)
- Systems Theory

Anthropological Paradigms relevant to Human Ecology *sensu lato*
- Structuralism
- World Systems Analysis
- Political Economy (Marxist Anthropology)
- Population Ecology (Demography)
- Identity (Cultural Studies)
- Kinship and Ethnicity
- Interpretive and Symbolic Anthropology

Ecological Anthropological Paradigms relevant to the study of Human Ecosystems
- Cultural Ecology (Functional Materialism)
- Political Ecology (Expanding Contextualization)
- Ethnoecology
- Historical Ecology
- Biocultural Studies
- Evolutionary Ecology (Environments of Evolutionary Adaptedness)
- Analysis of Environmental Discourse

Box 5. Definitions of Bioecology: Population vs. Ecosystems (Modified from Pickett, Kolasa and Jones 1994, Box 1.1).

Population Paradigm
The study of interrelationships between organisms and their surroundings (Ricklefs 1977). The study of the interactions that determine the distribution and abundance of organisms (Krebs 1978).

Ecosystem Paradigm
The study of the structure and function of nature (Odum 1971), particularly the patterns of matter and energy flow.

Toward Integration
Populations are conceived as parts of ecosystems. Thus, a holistic bioecology would entail the study of the relationships between organism variation and the flow of matter and energy among organisms, systems, and their multiple environments.

man ecological levels something like that depicted in **Table 1**. Human ecosystems may be recognized at each of these levels, a potential starting place for conceptual integration across subdisciplinary paradigms. The central role of *information* in human ecology makes such integration more plausible than it would be in biological ecology, where the integrative potential may have to come from focusing on questions that lie at the intersection of the subdisciplines, questions that cannot be addressed by either of the two paradigms already described acting alone.

In the development of an integrated theory of human ecosystems, it is important to remember that no single objective of theory takes precedence over all the others. Every theoretical objective contributes to the dialog of understanding. This pluralistic view should help alleviate unproductive and damaging debate about what single method is best. Moreover, a theory of human ecosystems could at once be evolutionary/historical, dynamic/dialectical, abstract/empirical and general/specific (**Table 2**). In restricted domains, critical theory, for example, might be self-contradictory and still contribute to understanding.

Fundamental Questions for an Integrated Human Ecology

In order to radically integrate sociocultural ecology and biophysical ecology, it is necessary to identify fundamental questions that might motivate or 'drive' this effort. Examples of such fundamental integrating questions might include the following.

To what extent are the causes of modern human ills inherent to the nature of our socio-cultural systems (Robbins 1999:ix)? Related to this, why do humans persist in destroying the life-support systems of the planet (Shepard 1982:1)? At best, will the next millenium see the conversion of a biologically diverse planet into a completely human-dominated noösphere (cf. Wyndham 2000:87)? Questions such as these may be addressed a number of ways at a number of levels. Perhaps new theoretical components are required to successfully address these questions, components that would not be recognized as relevant otherwise. Ultimate (or historically distant) causalities, as opposed to proximate causalities, may be involved, separated from considerations of system function and the ontogeny of reproducing patterns of daily life. Addressing these questions systematically may

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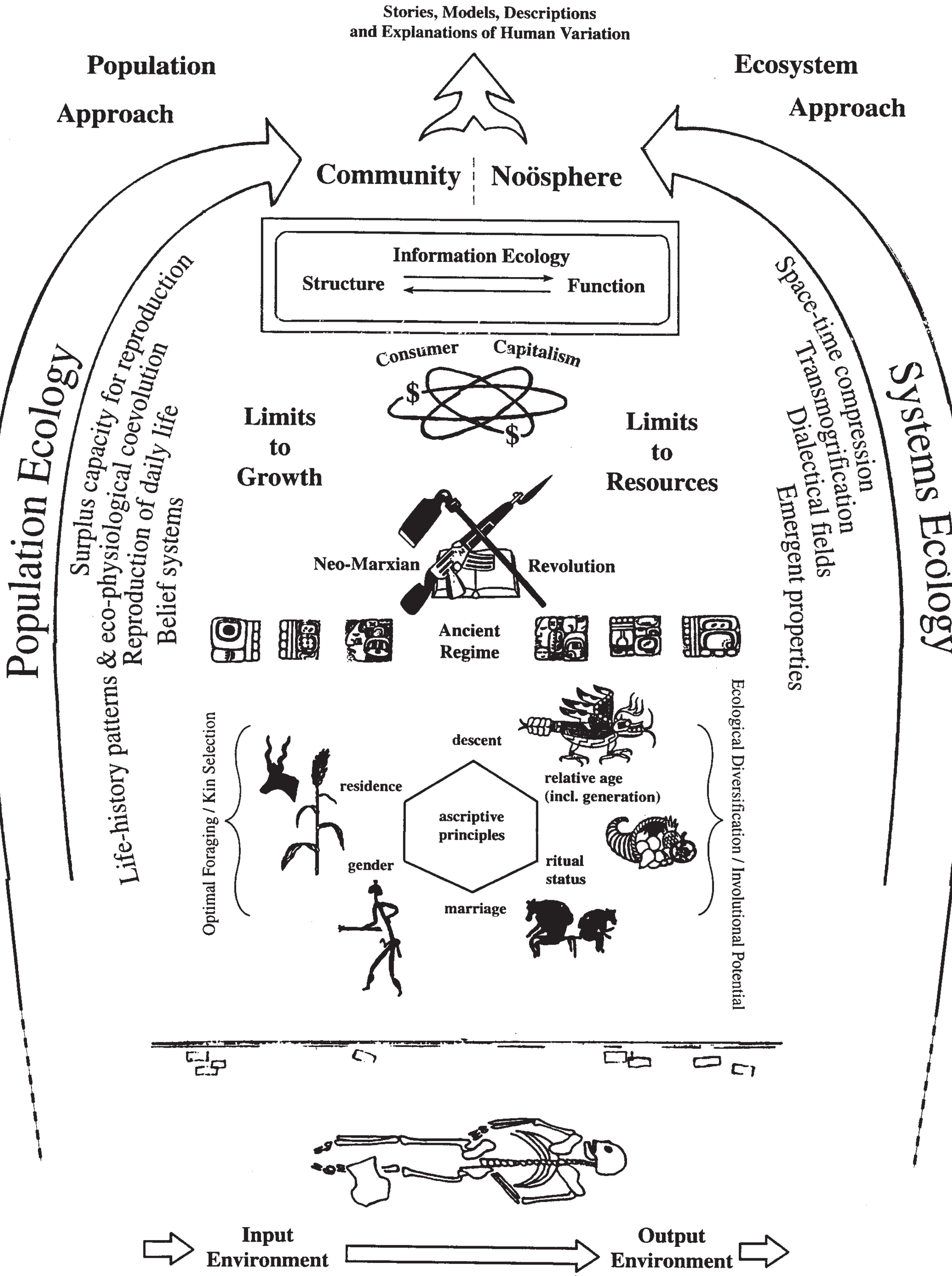

Figure 10. Ecological Anthropology: Subdisciplinary Moieties (Inspired by an unpublished diagram by G.W. Barrett depicting the population and ecosystem approaches in biological ecology).

In ecological anthropology the population and ecosystem approaches are only partially developed, but the strength of the discipline as a whole lies in the breadth of its subject domains, ranging from small-scale societies (many of which are only known archaeologically) to the modern world system. The traditional approach to integrating the information provided by the different subdisciplines is an additive one of combining findings into a narrative description of human variation.

force us to challenge the completeness, applicability or coherence of current theory, leading us to encompass components or relationships well outside currently accepted domains of explanation and understanding.

Methodological Tools for Investigating the Complexity of Human Ecosystems

Methodological tools are designed to effectively relate conceptual constructs to observable phenomena (**Figure 4**). Some of the methodological tools (m-tools) listed in **Figure 4** that are most relevant to the construction of a theory of human ecosystems include the following.

Expanding Contextualization

While used here for theoretical purposes, the method has applied beginnings in the East Kalimantan project of UNESCO's Man and the Biosphere program (Vayda 1983). For this project, units of analysis were sought by analyzing the social or spatial system by which resources were managed (Vayda 1983:267). To do this, initially a system of a small size was bounded, then made wider and wider or denser and denser (Vayda 1983:265). The strengths of expanding contextualization include: avoidance of assumptions that unnecessarily reify unit or system stability; allowance for flexibility in required time/money/effort; demonstration of practicality of results to lay people (policy makers); and better understanding of dynamism as well as stasis and persistence.

Marxian Method

In the Marxian method, priority is given to the 'How' (**Box 6**). Historical materialism creates "...an understanding of social and structural conditions based on internal relations of entailment rather than external ones of cause" (McKinlay and Taylor 1998), such that cause and effect become interchangeable (Harvey 1996:54). The role of theory is not to predict, but to explain through a set of generative and transformative principles that reveal possibilities. "The purpose of materialist inquiry is not to test...but to show...forms... domains...effects and transformative possibilities...The problem is to explore the forms and domains of operation" (Harvey 1996:67). Harvey's dialectical method closely parallels our system analysis, with emphasis on understanding processes, flows, fluxes and relations rather than on elements, content, things, fixed structures and static organizations. The dialectic (see **Figure 4**, methodological tools) prioritizes a search for fundamentally contradic-

Box 6. Marxian Method (After Harvey 1996).

In Marxian methodology, priority is given to 'the how.'

Questions take forms such as:

- can we show...
- are there circumstances that require us to rethink…
- can we track.... and what does this mean...
- what happens if...
- in what ways...
- and in what respects can this be regarded as... (Harvey 1996:67)

For method in building theory, we encourage the avoidance/rejection of the following Marxian assumptions and practices:

- inevitability of evolutionary historical processes
- exclusive role of the dialectic in causing evolutionary transformations
- privileged status of the working class (proletariat) as an historical agency
- ad hoc use of the concept of false consciousness to explain unsuccessful predictions

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tory forces. For human systems, dialectical fields can be informational with associated material/energy sinks, as well as the creative dialectics identified in Marxian (and Hegelian) methodology. In the former case, increasing amounts of energy may be dumped into points of structural contradiction in a human system, and these may become runaway sinks. In a 'bubble' economy, for example, governments will often keep throwing money at fear to boost 'consumer confidence' even though it is explicitly recognized that the market 'value' is drastically inflated relative to real production.

Postmodern Method

Postmodern and poststructural theorists are decidedly against grand theory, integration and universalism, yet there are several valuable methodological insights that a developing theory of human ecosystems can borrow from postmodern thought (**Box** 7). The postmodern position advocates critical social theory that analyzes and deconstructs the historical basis for our discourse/practice, our notions of truth and modes of intellectual domination, thereby hopefully undermining their appearance as the natural, i.e., inevitable, outcome of sociocultural evolution (cf. Poster 1984:159). This point of view provides valuable shifts in methodological perspective that forces us to continually recognize the constructed nature of theory itself. Also, the production and reproduction of 'power,' a central theme in postmodern and poststructural analyses (cf. Russell 1938; Foucault 1972; Jameson 1991), is clearly relevant to the evolution of human ecosystems.

Causality

The targets and some of the aspects of causal explanation are shown in **Box 8**. Causalities may be conceptualized in a number of ways, including direct, indirect, ultimate and proximate.

Box 7. Postmodern Method (After McKinlay and Starkey 1998).

Similar to the Marxian approach, priority in this method is given to "the how" (Deetz 1998:153). But the objective of postmodern methodology is to uncover the rules that regulate and govern social practices that are unknown to the actors involved. To do so:

- use is made of jarring or shocking images to force us to see the ordinary with fresh vision, to confront the strangeness of the familiar (McKinlay and Starkey 1998:5)
- the subject is taken from its central position (Burrell 1998:22)
- the ideas of human progress and enlightenment are questioned (Burrell 1998:22)
- care is given to the meaning of small details, including the attempt to record accidents, chance and lies (Burrell 1998:22)

The Deconstructive Gesture

The essence of the deconstructive gesture (via Derrida) is to investigate the relationship between explicit and hidden textual levels; to discover the limits of the text in order to "...understand the extent to which a text's objectivity and persuasiveness depend on a set of strategic exclusions" (McKinlay and Starkey 1998:11), or, why certain themes are never questioned, whereas others are condemned.

As a method for building theory, we suggest avoidance/ rejection of the following postmodern procedures:

- self contradiction, willful obscurantism and a determination to avoid totalizing at all costs (McKinlay and Starkey 1998:5)
- a "...complex, convoluted writing style...self-consciously adopted to escape from what is seen as the limitation and constraints of 'clear prose'" (Burrell 1998:15)

BOX 8. TARGETS AND ASPECTS OF CAUSAL EXPLANATION (From Pickett, Kolasa and Jones 1994, Box 2.2 Reproduced with permission of publisher).

Phenomena—observable events, entities or relationships of interest
Patterns—repeated events, recurring entities, replicated relationships, or smooth or erratic trajectories observed in time or space
Process—subset of phenomena in which events follow one another in time or space: these may or may not be causally connected
Cause—necessary entailment of one event or structure by another event or structure
Mechanism—a subset of cause: refers to a direct interaction that results in a phenomenon

The Aristotelian conceptualization of causality consists of four main components: material, efficient (mechanical), formal and final (**Table 4**). Three of the four causes work at different levels of scale, and can be considered to be hierarchical in nature (see **Figure 11**). The efficient cause will act on a small field of influence. The formal cause operates at the 'focal' level of observation. Events will transpire under conditions constrained and permitted by the final agents of causality (Ulanowicz 1997). Newton's *Principia* led to the dominance of the mechanical form of efficient cause in the physical sciences (Ulanowicz 1997). In the sciences influenced by Darwinian biology, however, final cause (based on purpose or design) dominates in the development of theoretical explanation (Gleick 1987:201). This is true of functionalist and materialist anthropology too, as seen in the search for final causes that explain cannibalism, religious practices, etc. and in the recent enthusiasm for evolutionary psychology's explanations of modern social behavior. Care must be taken to avoid preconceiving the kind of causality relevant to systems of interest; in most cases it is likely that at least both efficient and final causality play important roles.

Causation may also be either direct or indirect. Patten (n.d.) discusses both direct and indirect causation. Transactions are the observable transfers of resources between organisms. Relations

TABLE 4. ARISTOTELIAN CAUSAL CATEGORIES AND SOME EXAMPLES (Adapted from Ulanowicz 1997).

CAUSAL TYPE	Example 1: Building a House	Example 2: Writing about Information Ecology[12]
MATERIAL	Wood, mortar, stones, brick, etc.	Paper, ink, ideas, etc.
EFFICIENT	Carpenters, plumbers, etc.	Information ecologists
FORMAL	Blueprints	Chapter outlines
FINAL	Need for shelter	Perception of limitations in human ecology's understanding of human ecosystems

[12] For discussion see "Prospectus for Information Ecology" (Stepp 1999).

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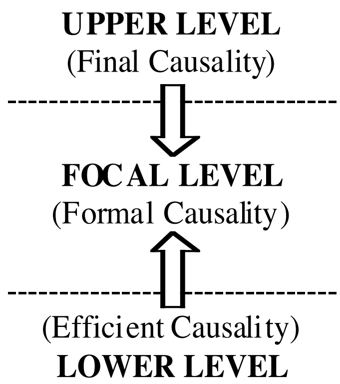

Figure 11. The Triadic View of Causalities Within Systems Science (Adapted from Ulanowicz 1997).
The formal causes operate at the focal level, while efficient causes operate from below. Final causes are imposed from above.

are the direct and indirect consequences of transactions. Indirectness is a separation between the organisms, a lack of direct connections between them. Indirect effects may influence a system through transactions that are not directly linked. Indirect causality is more important than direct causality in complex ecological systems (Patten n.d.).

Ultimate forms of causality refer to inherited structures or enabling and constraining conditions whose origins can be traced deep into the past. In order to understand present structures/systems (cultural, social, biological, physical) one must identify not only their genesis and context, but also their evolutionary histories. **Figure 12** depicts some important features of historical transformation. Initial conditions set the stage; boundary conditions restrict potential outcomes; and transformations rupture systems to effect significant change and mark periods of 'internal logic.' Internally, priority effects and echoes of the past provide historical continuity.

Hypothesis Testing

Theories that attempt universal explanations of human ecosystem phenomena are subject to a wide range of scale limitations that affect our ability to derive testable hypotheses (**Table 5**). Currently it is not possible for the individual researcher to judge the success of theory that forecasts or predicts over a very broad time scale or world system spatial framework. Creative attempts to transcend time/space compression and limitations of the individual observer include, for example, historical fiction and predictions based on thought experiments that incorporate current data into science fiction. Depending on the framework in question we find various shortcuts used in testing hypotheses.

The dominant mode of testing is the comparative method (**Box 9**), in which complex, multicausal models are subject to varieties of evidence. The conclusions drawn are usually probabilistic and contingent (**Box 10**). Because of the immature development of practitioner and theory in human ecology, predictions often seem riskier (**Box 11**) than conventional forecasting and prediction in other (non-human) fields of study.

Box 9. Modes of Testing (Modified somewhat from Pickett, Kolasa and Jones 1994, Box 2.3).

Experiment—manipulation of a system (e.g., organism) to generate a reference state or dynamic of known and repeatable characteristics
Comparison—examination of unmanipulated systems to determine their likeness or contrast in state or dynamics
Correlation—statistical relationship between measurements of two properties of systems

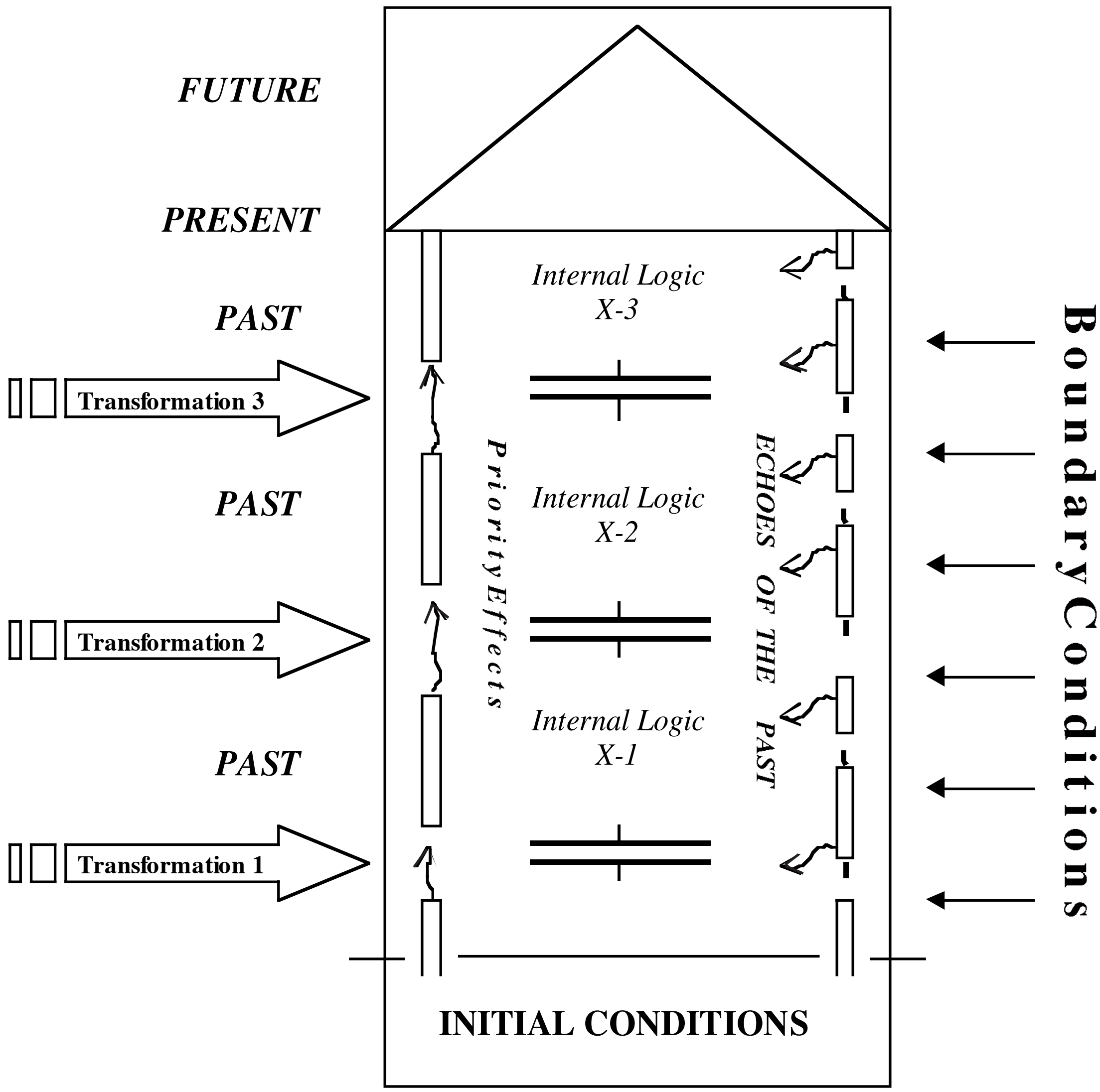

FIGURE 12. ULTIMATE CAUSALITY (Modified from Pickett, Kolasa and Jones 1994, Figure 7.4 [Originally Pickett 1991]).
This figure depicts the (causal) role of the past in enabling and constraining present and future conditions of ecosystems (applicable to any environment but especially the cultural and social). It employs a Braudelian (1980) view of historical transformations which, in combination with echoes from the past (such as features from the ancient regime), interact with internal logics of the time to produce contemporary conditions. Priority effects, or core principles (for discussion see Hallpike 1988) are persistent structures (e.g., cognitive, behavioral, social) that strongly influence historical development. Disjunctures imposed by historical transformations often create identifiable periods of social logics ('Internal Logics') that are marked as such in the record (e.g., the European 'Age of Reason'). Boundary conditions (such as carrying capacity, cognitive potential, fertility and mortality) and initial conditions constrain possible outcomes.

TABLE 5. HYPOTHESIS TESTING POSSIBILITIES: ATTEMPTS TO TRANSCEND OBSERVER MORTALITY.

Ecological Level	*Space/Time Matrix*	*Means of Forecast and/or Prediction*	*Time Scale for Data Recovery: Testing Hypotheses and Attempts at Circumventing Temporal Restrictions*
WORLD SYSTEM	Coarse scale Long term and Increasingly Complex E.g. Long waves of capitalism and technology vs. revolutions (transformations in structure)	Forecasting through projection of current states or alternatives into the future (e.g. science fiction) Predictions from thought experiments and mental models Retrodiction with historical fiction (comparative statics) Revolutions unpredictable? Extrapolation from past periodicity/ trends or system relationships. (e.g. Kondriatieff cycles)	Decades to centuries for testing (often revisionist historical analysis is employed) Short cuts attempted with place-for-time substitutions (e.g. 20^{th} century hunter-gatherers are assumed to be analogous to an earlier stage *x* in human evolutionary history)
POPULATION	Moderate scale Moderate complexity	Easier to forecast than World Systems Computer simulations of alternative possibilities	Years to decades Short cuts attempted with trend analysis
INDIVIDUAL	Fine scale Short term Involutional levels of psychological complexity	Predictions based on knowledge of identity, physiology, cognition, ontogeny, etc. Questions of free-will arise (e.g. existential stance)	Months to years Short cuts attempted with cross-sectional studies as substitutes for longitudinal studies Maximization of use of panoptic technologies as a way to continuously observe subjects (e.g. video, tapped phone lines, surveillance)

BOX 10. CONTRASTING REALMS OF TESTING (Modified from Pickett, Kolasa and Jones 1994, Box 2.4).

Falsification	**Verification**
Specific models or hypotheses	Complex compound models or theories
Narrow domain	Broad domain
Tightly designed experiments	Natural patterns or complex experiments
Univariate models	Multicausal models
Logical necessity of outcome	Probabilistic outcome
Simple concepts of evidence	Complex concepts of evidence
Prone to Type I error[13]	Prone to Type II error[13]
Opportunity to reject contingent answers	Opportunity to confirm or introduce doubt

[13] See Schrader-Frechette and McCoy 1993 for discussion.

Multiple Working Hypotheses

Chamberlin (1890, 1965) offers an important methodological discussion that can be partly summarized as follows. Hasty explanation quickly leads to the development of tentative theory. With unconscious bias, a favored tentative theory rapidly passes into an adopted theory, and then on to a ruling theory. The defects of this common chain of events have led historically to both the condemnation of theorizing in general, and to the method of the working hypothesis. Unfortunately, a working hypothesis easily becomes a controlling idea. To guard against this, Chamberlin urged the method of multiple working hypotheses. He points out that one of the chief merits of this method is that it encourages the development of complex explanations, with multiple causalities. The method also promotes thoroughness and a habit of parallel or complex thought wherein the practitioner appears capable of simultaneous vision from different standpoints. Phenomena appear to be viewed analytically and synthetically at once. He further notes that this type of complex thought cannot be expressed verbally in words, and that words and thoughts lose the close association that they usually maintain with those whose silent thoughts, as

BOX 11. KINDS AND FEATURES OF EXPECTATION (From Pickett, Kolasa and Jones 1994, Box 2.5. Reproduced with permission of publisher)

Prediction—a statement of expectation deduced from the logical structure or derived from the causal structure of a theory

Forecast—a projection of current trends or conditions into the future: such an expectation may not necessarily be derived from a theory

Safe predictions—those within the confirmed domain of a theory which, if incorrect, would not threaten the basic content or structure of the theory

Risky predictions—those outside the confirmed domain of a theory which would, if incorrect, bring down part or all of a theory; such predictions probe the limits of a theory

Classification—expectations of a group membership based on similarity or difference in state or dynamics of phenomena

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well as spoken thoughts, run in linear verbal courses. He confesses that one drawback of the method is that it introduces that difficulty in expression, and concludes that therefore there is a certain predisposition on the part of the practitioner to taciturnity. We should note that in the late 1800s, when Chamberlin wrote, graphical models had not yet been developed to the point where they could be used to express the kind of complex scientific thought that he knew so well from his own personal experience.

Concepts of Evidence

Concepts of evidence (**Box 12**) are the ways-and-means that allow for confirmation and rejection of the empirical content of theory, i.e. facts and well-established generalizations. The focal mode of thinking is white hat, the 'checking and re-checking mode' (see **Appendix**), in which it is important to specify limits to knowledge and common sources of error in judgement. Consilience with the D.I.F. criteria (Diversity, Independence, Fit, see **Box 12**) is the ultimate standard.

BOX 12. CONCEPTS OF EVIDENCE (Based in part on Pickett, Kolasa and Jones 1994, Box 2.6, plus Lloyd 1988).

Direct—including physical objects and eyewitness observations (vs. hearsay)
Indirect—by inference (circumstantial)
Expert Testimony—technical or other specialized judgements
Limits to Knowledge—recognition of limitations and common sources of error
Consilience
—convergence of different lines of evidence toward a unified conclusion
—accordance of two or more inferences drawn from different groups of phenomena
Diversity—variety in kinds of evidence
Independence—lines of evidence with separate origins
Fit—degree of accordance between expectations and outcomes/observations

B. CONSTRUCTING A THEORY OF HUMAN ECOSYSTEMS

In previous sections, we detailed the general nature of theory and its methodological applications. Now we attempt to use these methods to mobilize an intuitive theory of human ecosystems. We begin with the identification of theoretical components. (For explanation of the role of each component refer back to the Anatomy of Theory in Section I). We hope that by laying these out in an explicit though immature theoretical frame, we can illustrate the potential of holistic integration, provoke new ideas and invite contributions to theoretical development.

Basic Conceptual Components of Human Ecosystem Theory

Assumptions

Systems Comparability

One of the underlying assumptions of a theory of human ecosystems that seeks to integrate biophysical ecology and sociocultural ecology is that these are comparable systems. It is assumed that the heuristic device we call systems analysis uncovers common and interacting properties of both that yield fruitful insights. This assumption may become an accepted fact once it is fully recognized and initially tested.

Continuity

There are underlying commonalities to all human ecosystems that begin in the Upper Paleolithic and continue through postmodernity. These commonalities are reworked and given new expression with every major transformation in human history. Perhaps the most important of these is pursuit of the supernatural. (See Core Vectors in *Confirmed Generalizations*, below.)

Emergent Properties and Holism

Emergent properties of human ecosystems are manifested in ways that cannot be predicted on the basis of the addition of individual parts alone. Holistic analysis takes the stance that a whole is more than the sum of its parts.

Hyperfunctionalism

A strong assumption that underlies traditional human ecology is that of hyperfunctionalism, especially pseudo-Darwinian application of the concepts of fitness and adaptation. Contrary to this assumption, it has been recognized that culture is not inherently adaptive (rather, it may be hypofunctional), and many institutions do not exist primarily because they are useful (Hallpike 1988: 22). Particularly, a cultural trait's frequency and survival can owe more to its relatively easy social reproduction and the fact that it can be used to muddle through a variety of circumstances, rather than any adaptive efficiency (cf. **Figure 12**). For many institutions this can result in "survival of the mediocre" (Hallpike 1988: vi). In an integrated human ecology, *a priori* assumptions of functional efficiency and notions of human progress are no longer philosophically acceptable as unproblematic. However, it is essential to recognize them while in the process of developing theory, because unrecognized assumptions (confirmed or falsified) can create confusion and waste time.

Definitions

Because language is our primary mode of communication, any attempt by humans to integrate theory from multiple disciplines must carefully define terms. If terms are poorly defined, much time is wasted arguing at cross-purposes in low-grade communication. Some definitions essential to building a theory of human ecosystems include the following.

System

A set or assemblage of things, associated, connected or interdependent, so as to form a complex whole (Onions 1986). For human ecosystems the definition of system boundaries is often fluid and changeable depending on the focus of interest. Thus, in the same analysis, an organism might be bounded at the outer limits of its skin and later include its tools or built environment. The key is to set the boundaries of the system in ways that allow the symptoms of interest to be fully expressed. To be effective in analysis these boundary shifts must be clearly stated.

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Environment: Population View

From a population perspective, Andrewartha and Birch (1984) provide a Darwinian theory of the environment (**Figure 13**). Taking the individual organism (or a population of organisms) as the focal point, the environment consists of everything that might influence its chance to survive and reproduce. Functionally the environment can be divided into directly acting components (the *centrum*) and indirectly acting components (the *web*). The centrum is comprised of proximate causes. The four divisions of the centrum emphasized by Andrewartha and Birch (1984) are mates, predators, resources and malentities. The web is comprised of branching chains of indirect influences, the links in a chain being a living organism (or its artifact or residue) or inorganic matter or energy. The ecosystem construct modifies this concept of environment.

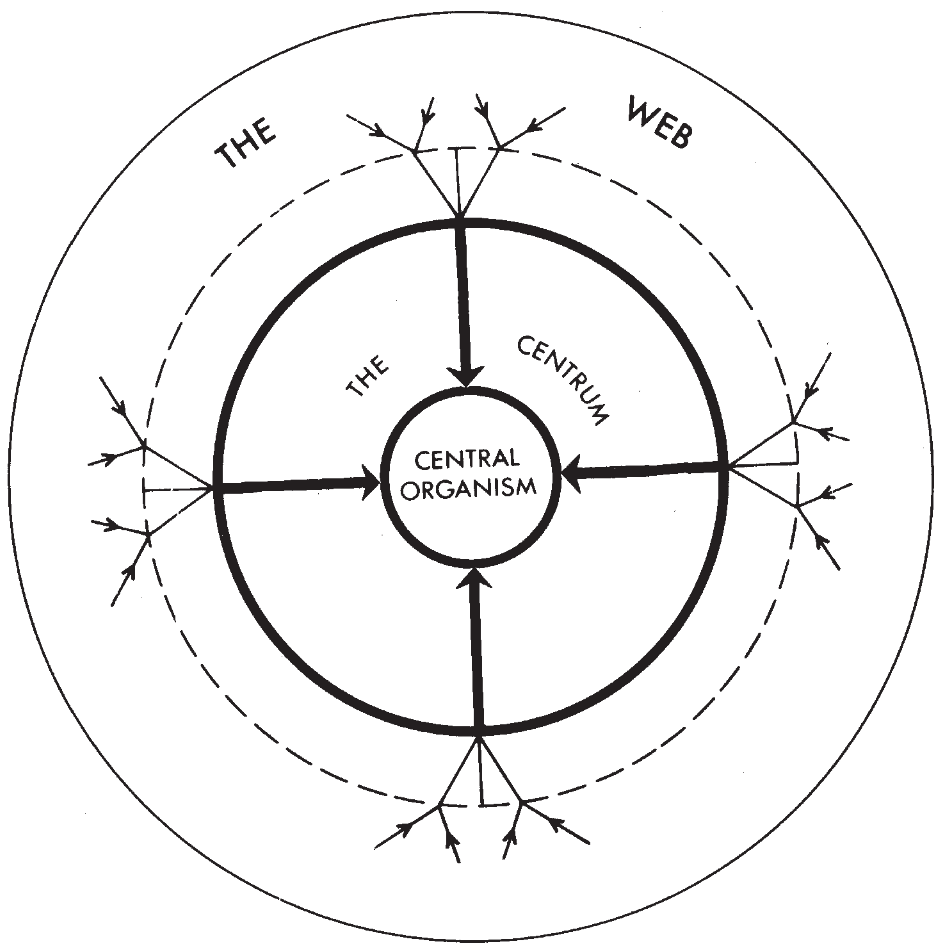

FIGURE 13. ENVIRONMENT AS CENTRUM AND WEB (Simplified from Andrewartha and Birch 1984, Fig. 1.01).

Proximate causes of changes in the physiology or behavior of an organism are placed in the centrum and recognized as directly acting components of environment; beyond the centrum everything else is part of the web of components that act indirectly through an intermediary or chain of intermediaries that ultimately influence one or another of the components in the centrum.

Environment: Ecosystem View

From an ecosystem point-of-view, Patten (1978) distinguishes between *input environment* and *output environment* (**Figure** 14). Ecosystem is defined as IE+S+OE (Input Environment + System + Output Environment). In addition, Patten's concept of ecosystem recognizes the significance of indirect causality and the importance of information flows in ecosystems.

Noösphere

The noösphere is the world transformed by humans and human thought. It is produced and maintained by increasing complexity of human interaction in cultural, social, biological and physical environments (see references in Wyndham 2000:87; and also the center illustration by Duranceau in this volume).

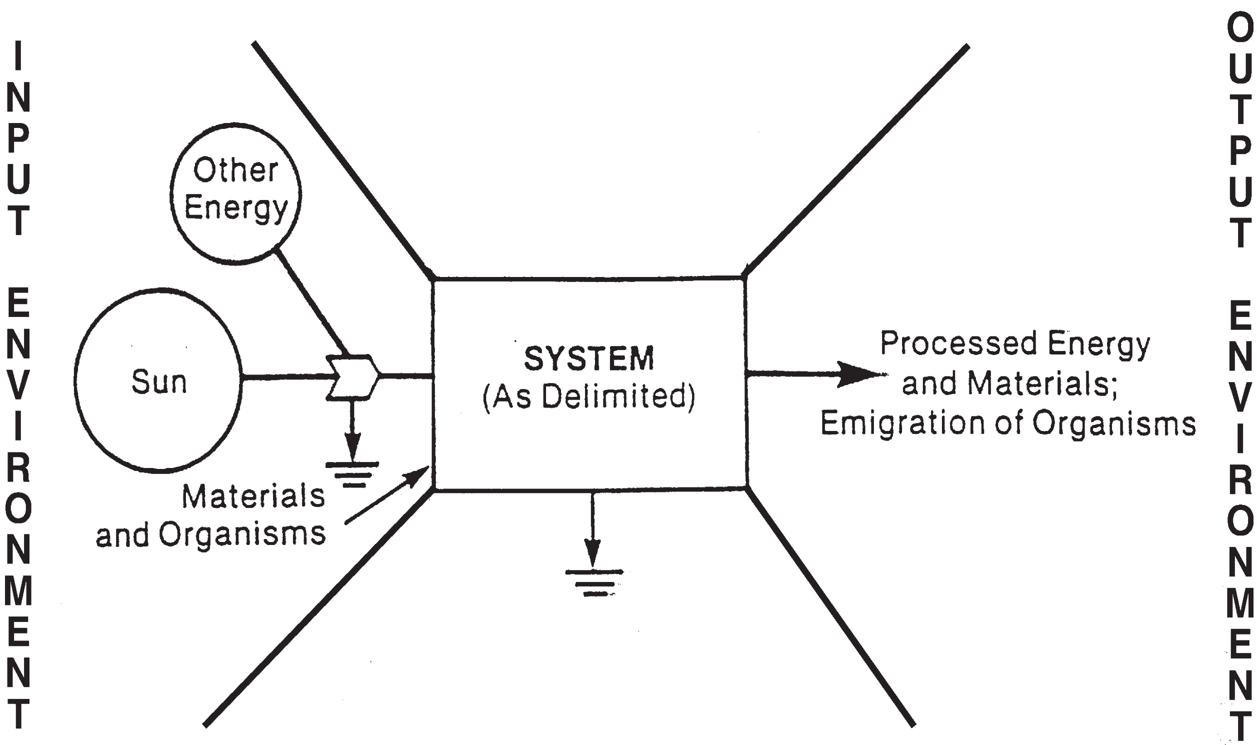

FIGURE 14. ENVIRONMENT AND ECOSYSTEM (Redrawn from E. P. Odum 1983; concept based on Patten 1978).

There are two environments, an input environment and an output environment, defined by the focal animal or system; altogether they define the ecosystem: IE+S+OE=ECOSYSTEM.

Concepts

Human Ecosystem

The human ecosystem concept adopted here is based on Patten's ideas (including the idea of filters/screens), combined with the concept of multiple environments (see **Figure 15**). Thus a human system can be thought of as a locus in a set of environments, which together with inputs and outputs constitute a human ecosystem. This concept can be expanded to a scaled hierarchy of human ecosystems (**Figure 16**).

We recognize the central role of information in human ecosystems. This is the starting point for most if not all identified observations, facts, confirmed generalizations and hypotheses developed to date.

According to Wilkinson (1995), with the evolutionary emergence of the nation-state, human ecosystems must be defined as entailing at least two somewhat independent state-level civilizations that are geographically separated, periodically hostile,

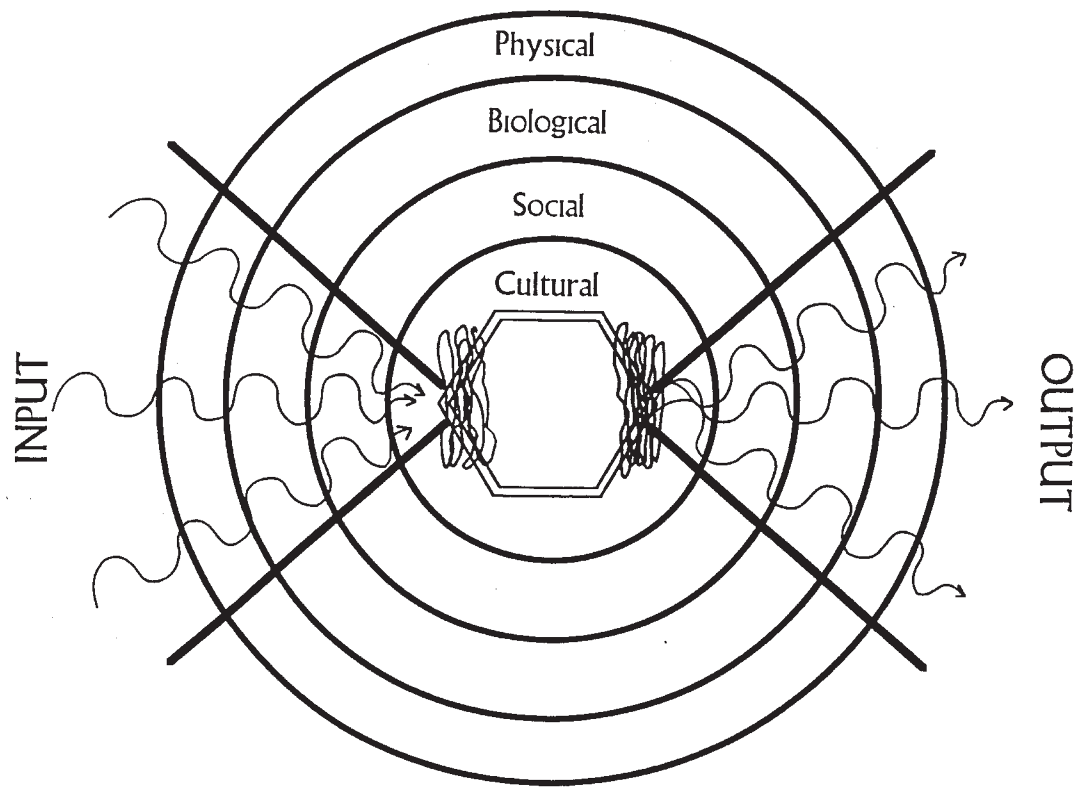

Figure 15. Partial Concept of Multiple Environments and the Human Ecosystem (Cover, Georgia Journal of Ecological Anthropology 1997).
Concentric spheres denote an evolutionary arrangement of the different environments, with an aggregated consumer symbol at the center. Information inputs and outputs to and from the system pass through epistemological filter/field/editor/screens.

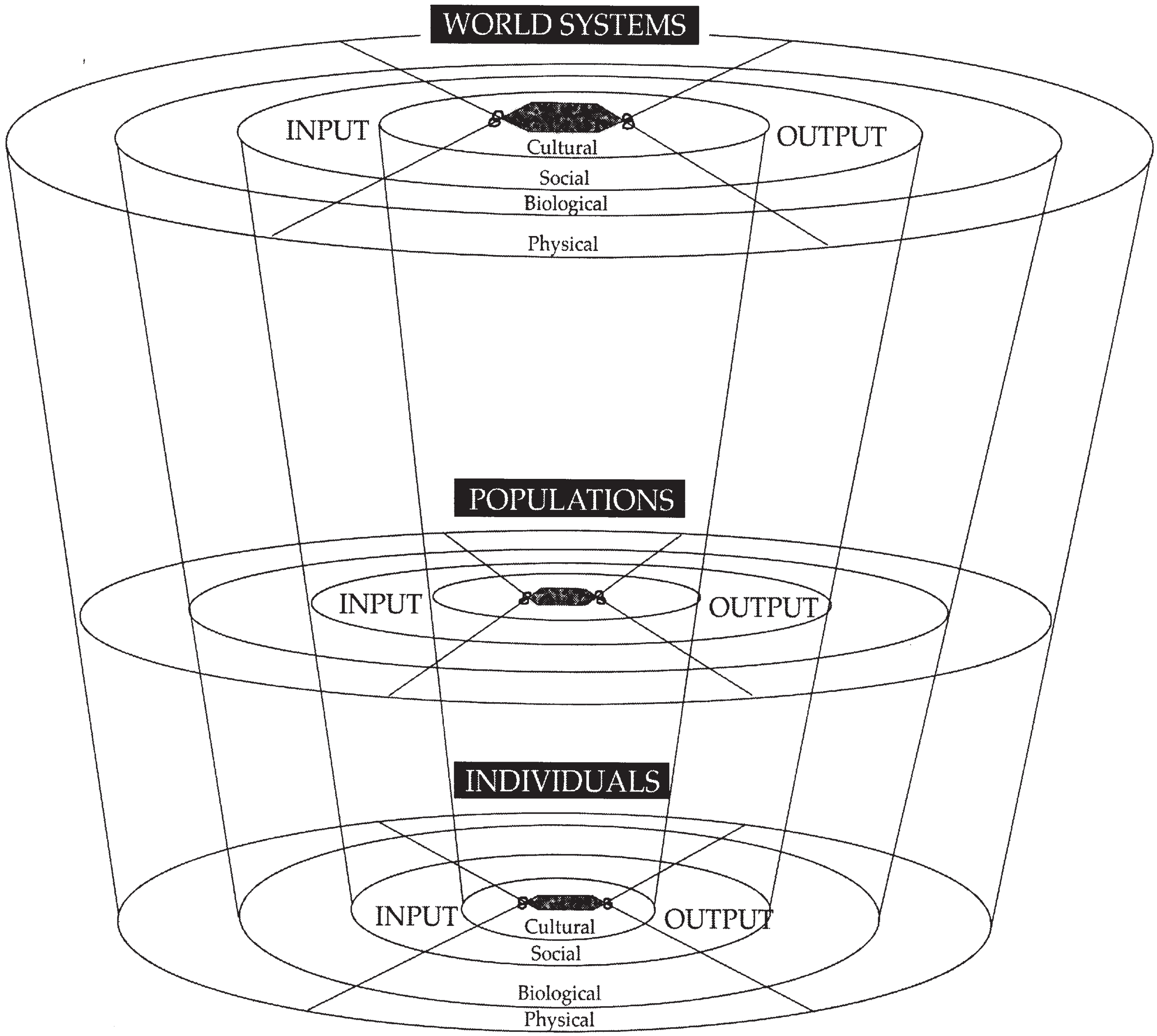

Figure 16. Partial Concept of Multiple Environments Applied to a Scaled Hierarchy of Human Ecosystems.

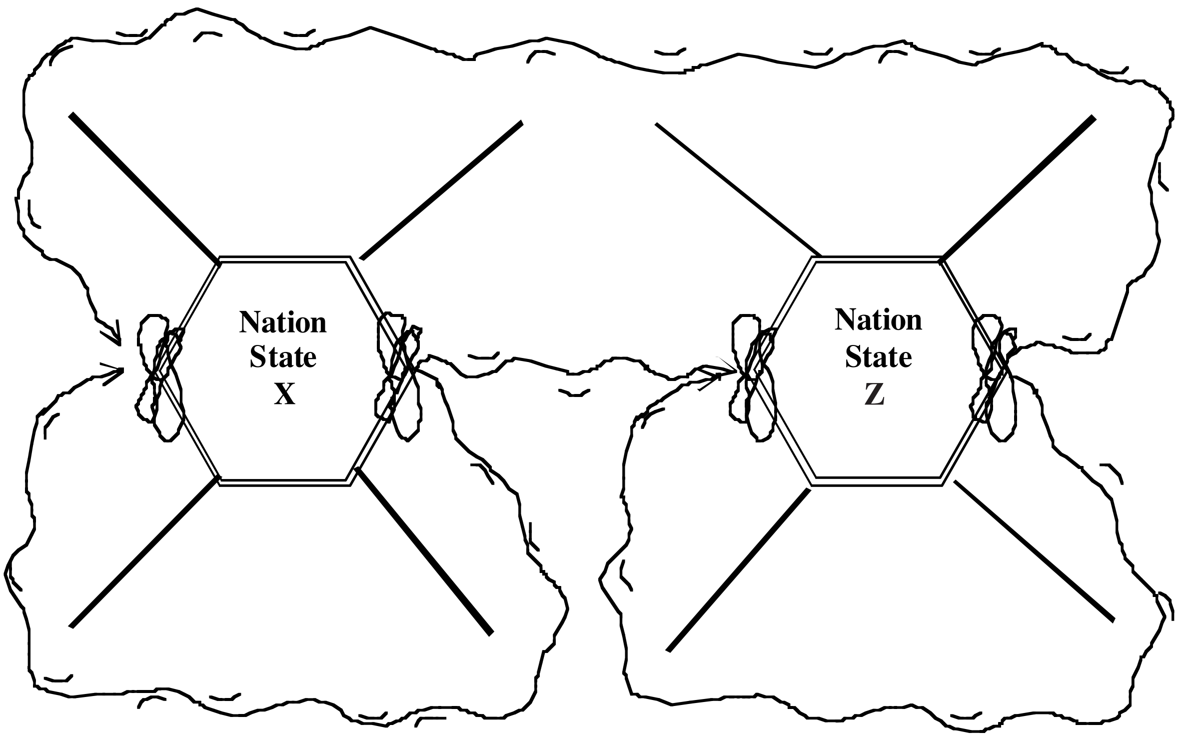

FIGURE 17. WORLD SYSTEM OF COMPETING NATION STATES (Concept based on Wilkinson 1995).
Central Civilization defined as the interaction of competing nation-states. The state-level human ecosystem is minimally made up of two competing nation-states. The flows are information and materials.

and competing socio-cultural systems (**Figure 17**). It is the interaction and interrelationship of competing nation-states (Wilkinson's Central Civilization), including warfare, that maintains nation-state human ecosystemic structure and function. Note that the definition of pre-nation-state human ecosystems may or may not incorporate Wilkinson's principle.

Evolution

Diverse possible evolutionary outcomes are often overlooked in theory. **Table 6** depicts a scheme relating mode and tempo of evolution in such a way as to clarify the concept, particularly in light of dichotomous debates regarding the nature of evolution, whether physical, biological, social or cultural. Ecosystem evolution may tend to result in networked mutualisms dependent more on indirect than direct causality (see Jorgensen 1992:340).

Hierarchy and Scale

The conceptual skills for traversing hierarchy and scale with ease must be acquired for application of human ecosystems theory to different organizational levels and temporal junctures (for a thorough treatment see Allen and Hoekstra 1992). This entails skill at recognizing parts of a system (e.g., cells) and then subsuming the parts into larger systems (e.g., individuals) which themselves become subsystems of still larger systems (e.g., communities, nations) and so on. Systems at different scales may exhibit different properties. Braudel's (1980) *longue durée* of human history is one example of the heuristic value of situating event histories within larger structural patterns over time.

Paradoxical Ontologies, Strange Loops and Perverse Functions

Paradoxes and perversities are ubiquitous in human systems (cf. Smith and Berg 1987). Specifically, we have identified these as 'paradoxical ontologies' and 'perverse functions.' A paradox is defined in early usage (c.1570) as a statement or condition that is apparently self-contradictory, but possibly true. Bateson (2000) casts a paradox as a question that requires us to take sides—both sides at once (the 'double bind'). In any case, paradoxical ontologies exist throughout hierarchical levels in any system, expressed in many ways, including visual art and ritual systems. Paradoxical ontologies are a primary function of being human. Graphic representations expressing complexity often incorporate paradoxes and contradictions, depicted as 'strange loops' or tangled hierarchies (Wilden 1986). Wilden identifies the paradoxical characteristics of human information environments as semiotic oscillation. As our brains attempt to reconcile contradictory information, visual input and cognitive processing oscillate back and forth between the two simultaneous but apparently contradictory interpretations. A related category is that of perverse function, characterized by irony and juxtaposition. Perverse functions are a secondary characteristic of humans acting together in complex, socially constrained environments. Political cartoons are typically commentaries on perverse functions in contemporary society.

TABLE 6. SCHEME RELATING EVOLUTIONARY MODES AND TEMPOS: A PARTIAL MATRIX OF POSSIBLE COMBINATIONS.

TEMPO		MODE: *Non-Directional Change*	MODE: *Directional Change (unfolding, progressive, cumulative vs. cyclic)*	
Fast Change	Short Period	transmogrification	?	EXTINCTION
Fast Change	Long Period	?	progressive transformational discontinuous	EXTINCTION
Slow Change	Short Period	drift	? ? ? ?	EXTINCTION
Slow Change	Long Period	drift	? ? ? ?	EXTINCTION
No Change	Short Period	dynamic stability is the dominant process: the system maintains structure and identity; 'stabilizing selection'		
No Change	Long Period			

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Externalized Cognition

Externalized cognition is the externalization of knowledge/cognition manifested in communicative signs, behavior or material artifacts. For humans, language is the most obvious form of externalized cognition, but the domain includes such things as smoke signals, rolex watches, maps, art, blitzkrieg, ritual acts, traffic signals and the abacus (cf. Gumperz and Levinson 1991). Because of its role in the evolution and maintenance of sociality, externalized cognition can be considered a generative principle for human ecosystems. Complex social structures are based in part on the differential distribution of externalized cognition (a *Confirmed Generalization*).

Empirical Content Of Human Ecosystem Theory

Observations

System Controls

Human (social) systems are not closed teleological systems controlled from outside, but are ecological networks in dynamic interaction with other systems, including other social systems and biophysical systems. They have both centralized and diffuse/varied control mechanisms (Patten and Odum 1981; see **Figure 1.b**), apparently dominated by indirect causality.

Insular Logic

All belief systems have an insular logic; i.e., they are closed within the framework of their foundation assumptions, impervious to input not specified as legitimate in advance. "… In this web of belief every strand depends upon every other strand, and a [member of the cultural system] cannot get out of its meshes because it is the only world [s]he knows" (Evans-Pritchard in Horton 1993:222). Insular logics are usually dynamic systems; to understand one part an outsider must often make the effort to understand the whole. The reorganization of insular logics may cause major transformational disjunctures (in psychological and social systems), particularly when foundational assumptions are effectively challenged. An example at the individual level is the 'Born Again' or conversion experience. Conversely, general system crises may provoke explicit recognition of previously unacknowledged assumptions. For example, after the 1929 U.S. stock market crash the role of consumer confidence and 'belief in the system' both in creating and bursting financial bubbles became common knowledge.

Accepted Facts

Humans Sacrifice Enormous Amounts of Wealth in Pursuit of the Supernatural

In Iron Age Denmark, valuable enemy ships were dragged inland and scuttled along with swords, axes, and horses as offerings to lake deities in gratitude for victory in battle (Klesius 2000:31). The Pharoahs of Egypt sequestered vast fortunes for their voyages in the afterlife. Trillions of dollars have been spent on space exploration, which serves ideological purposes for earthlings, inspiring faith in the manifest destiny of our continual territorial expansion and our status as chosen capitalists-in-control-of-the-world-and-beyond. Are these seemingly irrational expenditures the norm for all societies?

Confirmed Generalizations

Causality in Complex Human Systems

Forrester (1969:9-10,110) provides some notes on causality in complex human systems. He points out that in complex systems cause and effect are often not closely related in either time or space. Further, apparent causes close in time to observed symptoms are usually not true cause and effect relationships, but instead coincident symptoms arising from the dynamics of system structure. He notes that for human social systems, causes are usually found, not in prior events, but in the structure and policies of the system. These generalizations compliment Patten's emphasis on the importance of indirect causality in non-human ecosystems (see Causality, above).

Wallerstein (1999:1; following systems theory of dissipative structures cf. Prigogine 1984) posits varying causal effects historically in human systems at different stages of development. For human systems during phases of normal development, large

inputs have small outputs (i.e., it is difficult to change the course of history), whereas during a phase of demise (or bifurcation), small inputs have large outputs (seemingly trivial events trigger drastic change). Causal direction or outcome may be inherently unpredictable, especially during periods of system demise.

Unique Properties of Human Ecosystems

Human systems demonstrate a number of unique ecosystem properties, including the following. (1) Human systems have internalized representations of the system itself and can generate or reformulate goals for all or parts of the system (G. Bateson in M.C. Bateson 1972:102). This adds reflexive informational complexity to ecosystem analyses, although it is unclear how effective internal direction is in the long-run. (2) Expression of the maximum power principle (see H.T. Odum 1983) by modern human ecosystems on a global scale is increasingly destructive of biological and cultural diversity. Global capitalism is the latest expression of this vector.

Core Vectors of Human Ecosystem Evolution

At least three core vectors are common processes in human ecosystem development. The human practice of externalizing cognition (see Concepts, above) is the generative principle underlying all of these vectors. The three core vectors interrelate involutionally over time. (1) *Technosubstitution*: the progressive substitution of technological structure (fabricated and domesticated) for biological and physical structure. (2) *Historical Canalization*: the strong (though not exclusive) role of the past in determining historical trajectories (**Figure 12**). Fundamental structural change is difficult because, among other reasons, an increasingly architectured (technosubstituted) output environment dominates the informational input environments. Insular logics, taboos and voluntary blinders also play a role. (3) *Seeking the Supernatural*: ubiquitous among human systems, at least for the past 30,000 years, human relations with the supernatural (informational, material and energetic) cannot be ignored in an integrated or holistic understanding of human ecosystems.

Derived Conceptual Components Of Human Ecosystem Theory

Hypotheses

Examples of as-yet-untested hypotheses include the following. (1) "The cybernetic nature of self and the world tends to be imperceptible to consciousness" (G. Bateson, in M.C. Bateson 1972:16). Related to this is the (emic) perception of imagined human environments as unlimited in resources and lacking in even material feedback loops (i.e., we can throw trash 'away'). (2) With the advent of the nation-state, biophysical environments become thought of as less and less important relative to interpolity information interactions, which come to dominate both input and output environments.

Models

A basic conceptual model for human ecosystems is that of a system locus in *multiple environments* (**Figure 15**). Information 'flows' in and between physical, biological, social and cultural environments (a general evolutionary sequence). Information inputs and outputs are subject to epistemological filter/field/editor/screens, located both inside and at the outer boundaries of the system (see Stepp 1999 for discussion).

Framework and Structure of Human Ecosystem Theory

Framework

Human ecosystem theory does not yet have a coherent theoretical framework or structure. Relationships between conceptual devices still need to be laid out. Only a beginning has been made at working out assumptions, theoretical constraints and the conceptual inputs and outputs for theoretical models. Some basic requirements for framework development have been identified, however. For one, the theoretical framework must be open, making integration with other existing and evolving ecological and anthropological theory possible. For another, the scope of the theory must take into account several thousand years of human sociocultural evolution.

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Domain
The minimal domains of inquiry for a comprehensive theory of human ecosystems includes hunting and gathering systems (late Pleistocene and early Holocene); horticultural based systems; wood-fuel based ancient states and empires, fossil-fuel nation-states (first to early second industrial revolution; modernity) and the post-WWII world system.

Translation Modes
The application of theoretical frameworks to the complexities of the 'real-world' can help identify errors of abstraction and idealization, making it a most useful and sometimes indispensable step in the development of theory. Forrester (1969) provides an illustrative example of the potential of applying theoretical models to aid understanding of real-world problems. In the late 1960s at MIT he participated in a series of informal discussions with John Collins, a former mayor of Boston, and others, exploring the applications of his research on the dynamics of complex systems to modeling pressing urban dilemmas of the time. Not only did he find that the concepts and modeling framework that he had developed were applicable to urban problems, but that the interaction with people intimately concerned with the inner workings of this human ecosystem confirmed generalizations and generated new hypotheses about complex systems in general. For example, complex systems are usually counterintuitive and complex human systems stubbornly resist top-down policy changes (Forrester 1969:109).

The application of human ecology theory to management goals (cf. Hens *et al.* 1998) may yield fruitful insight into the causal effectiveness of conscious purpose in system evolution. Bateson (1972:31) noted the need for "a formal description of the ways in which human planning and applied science tend to generate pathology in the society or in the ecosystem or in the individual." Research taboos may be most easily identified in this phase of application and testing, as restrictions on the acceptability of overly negative or hopeless conclusions about human systems become apparent when presented to the public. Real understanding of human ecosystems is a prerequisite for effective biological and cultural conservation efforts worldwide.

Other applications and their translation modes are political in nature. In the past, social revolutions, civil rights, and liberation movements have all depended on increased public understanding of the nature of the social systems they lived in (see Wallerstein 1999:19-33 for specific examples). Conversely, advances in understanding the nature of human ecosystems might give political control advantages to unintended agents (cf. Davis 1984, an example of governmental use of social science techniques in policing efforts).

C. ONTOGENY OF HUMAN ECOSYSTEM THEORY

We are at the intuitive stage of theory development for human ecosystems (see **Figure 9** and **Box 3**). Some progress has been made in developing definitions and basic concepts. The empirical content is largely descriptive and unconsolidated. Models are just beginning to be developed. Framework is incipient.

It is possible that most of the components for a useful theory of human ecosystems already exist. If so, these components are widely dispersed among many different disciplines. The challenge is to bring these components together in the development of theory. How this is done depends on the relations of human ecology to the broader intellectual community and the public at large.

D. ECOLOGICAL UNDERSTANDING AND THE INTELLECTUAL COMMUNITY AT LARGE

Developing a theory of human ecosystems is more than impractical. It is taboo.

Practically Impossible?

Pass the buck. Some other discipline should be responsible. Not mine. Certainly not me. I don't have

the knowledge required for such a monumental task.

Understanding human ecosystems requires radical synthesis. It requires an integration of knowledge and perhaps social discipline previously limited to warfare. It requires creativity previously limited to practitioners of the arts and humanities. Development of a working theory of human ecosystems may take hundreds if not thousands of years.

True, a diversity of expertise is needed. True, you can't have empirical holism in the sense that *all* of the details are included in a model with the aim of understanding the ecosystem. But conceptual holism is possible. Increased understandings plausibly follow on attempts at holistic conceptualization.

In our capitalist/postmodern world, understanding of social phenomena as holistic systems processes with a central informational component is perhaps most developed in economics. The global economy is commonly referred to as a system with hierarchical structure (local/regional economic subsystems), flows (both material and informational), and varied inputs and outputs. For example, a practically possible model for the initial development of human ecosystem theory is apparent in the analysis of the recent so-called Asian Financial Crisis. The role of panic in precipitating economic collapse was recognized in media coverage, though the speculation and financial manipulations underlying the panic remained primarily as subtext, while geopolitics remained sub-subtext (Wallerstein 1999:49). A world systems perspective reveals cyclical predatory trends in the relations between First World economies and Third World economies. The former speculates in 'development' of emerging economies and newly opened labor markets (but pull out when that seems more advantageous), while the latter is increasingly bound and controlled by debt restrictions (and deals with the psychological, cultural and social repercussions of collapse).[14] This system is supported by international infrastructures largely controlled by First World institutions (IMF, WTO, World Bank) that lend capital to emerging economies in return for *de facto* control of profitable sectors of the political economy.

Understanding human ecosystems at this level is clearly a task that requires contributions from a wide range of disciplines. It requires intellectual team-work.

Taboo?

Human systems resist and prohibit complete disclosure of how they actually work. It may be intellectually taboo to ask certain questions about the system. For example, can we include questions about basic human/system factors such as military influence in models of current human ecosystems?

Part of the ancient regime, the military is one of the defining institutions of civilization, setting paradoxical standards for the emerging cultural concept of efficiency (e.g., mass destruction), and expanding the realm of the supernatural (e.g., nuclear winter). Wilkinson's Principle (**Figure 17** and text above) recognizes that nation-states exist within the framework of competing interaction with 'foreign' enemies. Enemies must be created at the level of the nation-state in order for civilization to exist.

The influence of the military on the development and maintenance of modern civilizations is generally unacknowledged. What is apparent is that in warfare the military system pushes the limits of social organization. It also pushes the limits of technology. But what of its role or influence in 'peace time'? There may be a liberal taboo on investigating the connection between the military and social organization in 'peace time,' but it is clear that the contributions of the military-industrial complex are important in organizing and training leadership (McKinlay and Starkey 1998) that maintains the social hierarchy. Technological hand-me-downs in 'peace time' also contribute to reinforcing patterns within the general cultural system (e.g., cell-phones, e-mail, GPS).

[14]After pressure from the International Monetary Fund prompted Indonesian General Suharto's resignation in 1998 (he is estimated to have taken $16 billion with him), his successor President Habibie called for the Indonesian people to work together to overcome the country's economic crisis. He called on them to conserve scarce resources by fasting on Mondays and Thursdays of every week (Galeano 2000:177).

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These influences are not accurately reflected in the energy flow models of modern nation-states. Indirect informational effects are dominant in the unconsciousness of 'peace time.' But even recognizing topical taboos helps us understand the nature of the system. It might be suggested that the extent of totalitarian control in our ecosystems can be measured in part by the thoroughness of taboo on investigating the role of the military. Institutional secrecy and strategic exclusion of certain kinds of system information requires methodology that exposes system structure, relations and histories. For this task a postmodern methodology may be prescribed as the most effective so far at identifying taboos and exposing hidden patterns and assumptions.

E. BACK TO THE BEGINNING

As an ending to this Prelude to Human Ecosystems we should return to Rappaport's (1971, 1984) model of ritual regulation and ecosystem function among the Maring (**Figure 1e**). The boldness of his accomplishment was in combining native and academic views of major human ecosystem components in a cybernetic model. Whether the system is (was) cybernetic is open to question. We are some distance from understanding the manner and degree to which human ecosystems are self-regulating.

In this essay we have laid out a prelude to a theory of human ecosystems that is still at the intuitive stage of development (**Figure 9**). We have emphasized comparatively simple conceptual themes, particularly the importance of including information, belief systems, worldviews and pursuit of the supernatural in our understandings of human ecosystems. Rappaport's model not only includes the supernatural, but also the cycle of warfare and peace, linked to the economic system. We propose that a similar systems approach is necessary to understand not only 'traditional' small-scale societies, but the global postmodern world as well. It is up to future generations to break the taboos that prevent the development of such understanding.

Appendix

The Six Thinking Hats Method
Notes from de Bono 1990b

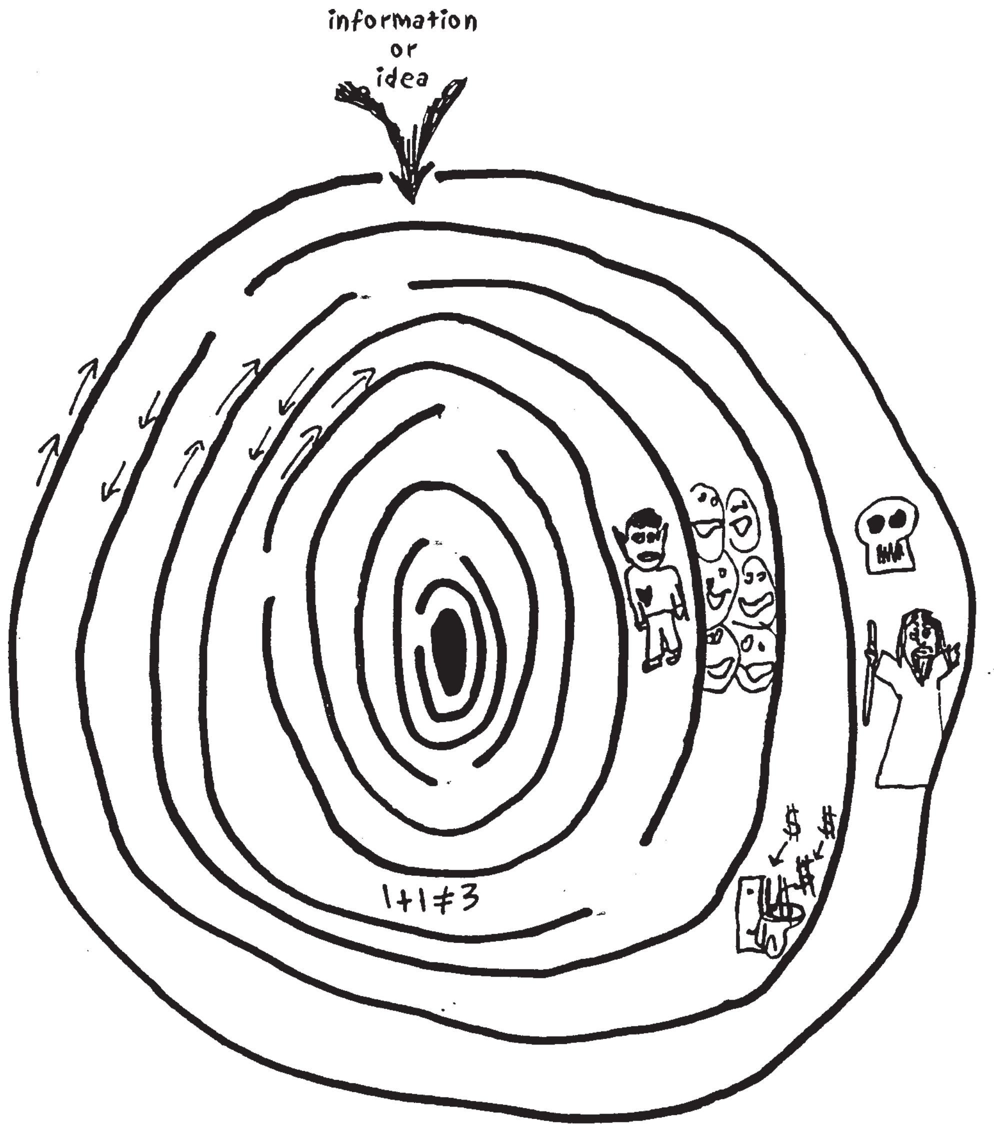
De Bono's six thinking hats method is designed to switch thinking away from the normal argumentative style to a mapmaking style. The purpose of the hats is to unscramble thinking so that one is able to use one thinking mode at a time, alternating them in a constructive way. The six thinking hats do not cover every possible aspect of thinking, only the main modes.

The idiom of the hats is very artificial. This is its greatest value. The hats provide an innocent formality, a naïve convenience for requesting a certain type of thinking, either of oneself or of others. In social contexts, where teamwork is important, they establish some rules for the game of thinking; all the team players are aware of these rules. The more the hats are used, the more they become part of the team thinking-culture. Focused thinking becomes much more effective, a brisk and disciplined approach instead of wasting time in argument and pointless talk around the topic of discussion. Without the formality of the hats, some participants may remain permanently stuck in one mode of thinking, usually the black hat mode.

At first you may feel a bit awkward using the different hats, but that soon passes as the possibilities of the system become apparent.

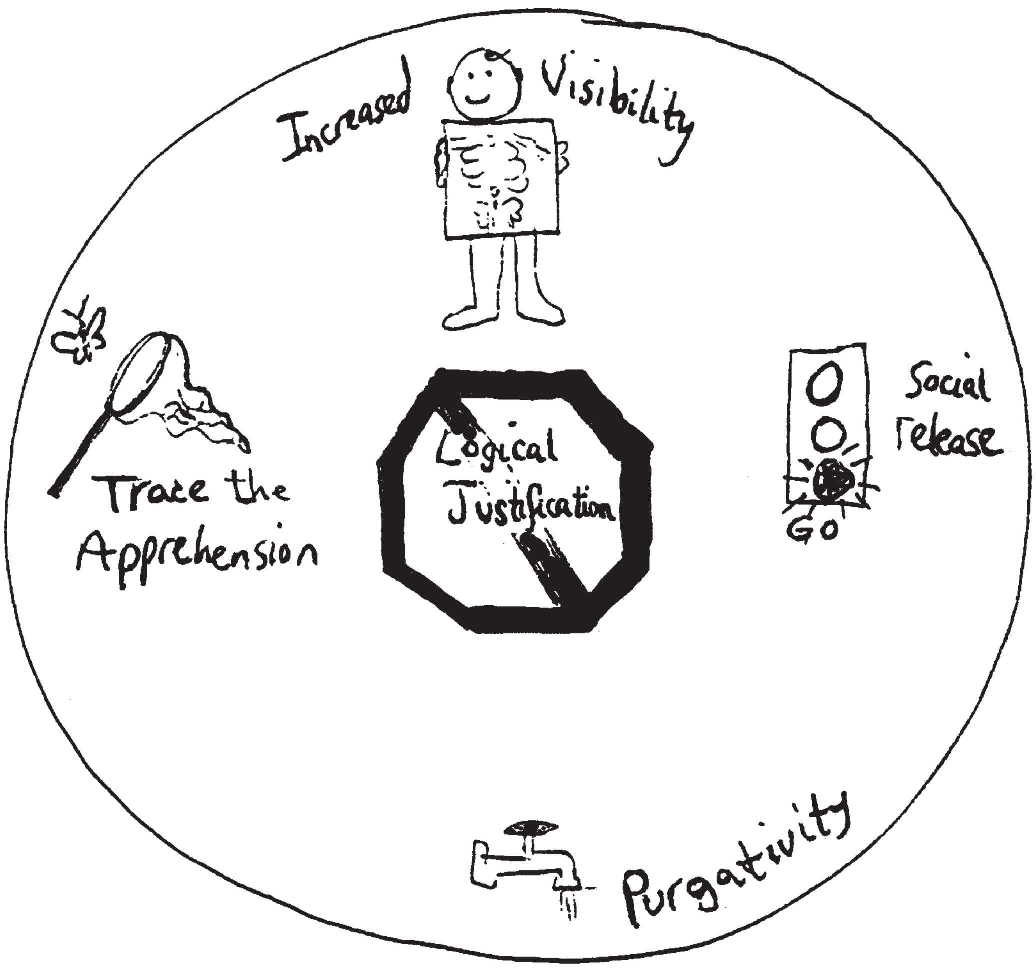
Black Hat

Devil's advocate, negative assessment, why it won't work. What is wrong, doesn't fit, incorrect, risky, dangerous, in error. Negative questions, not argument.



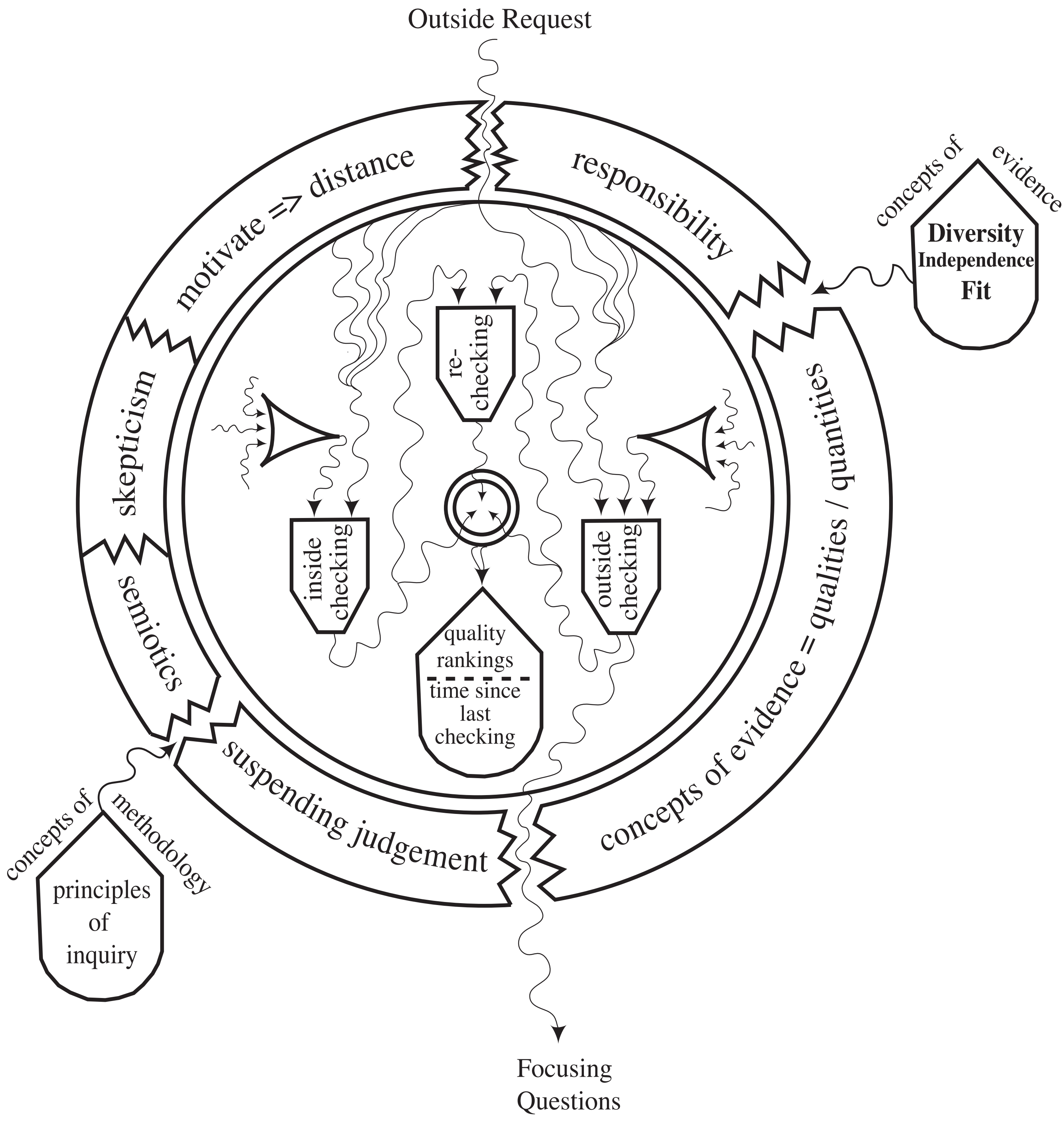
Red Hat

Seeing red and sharing euphoria, making "feelings" visible. Stating values, but not trying to justify them, nor attempting to make them logical. Also sharing complex judgements such as hunches, intuitions, senses of, and aesthetic tastes.



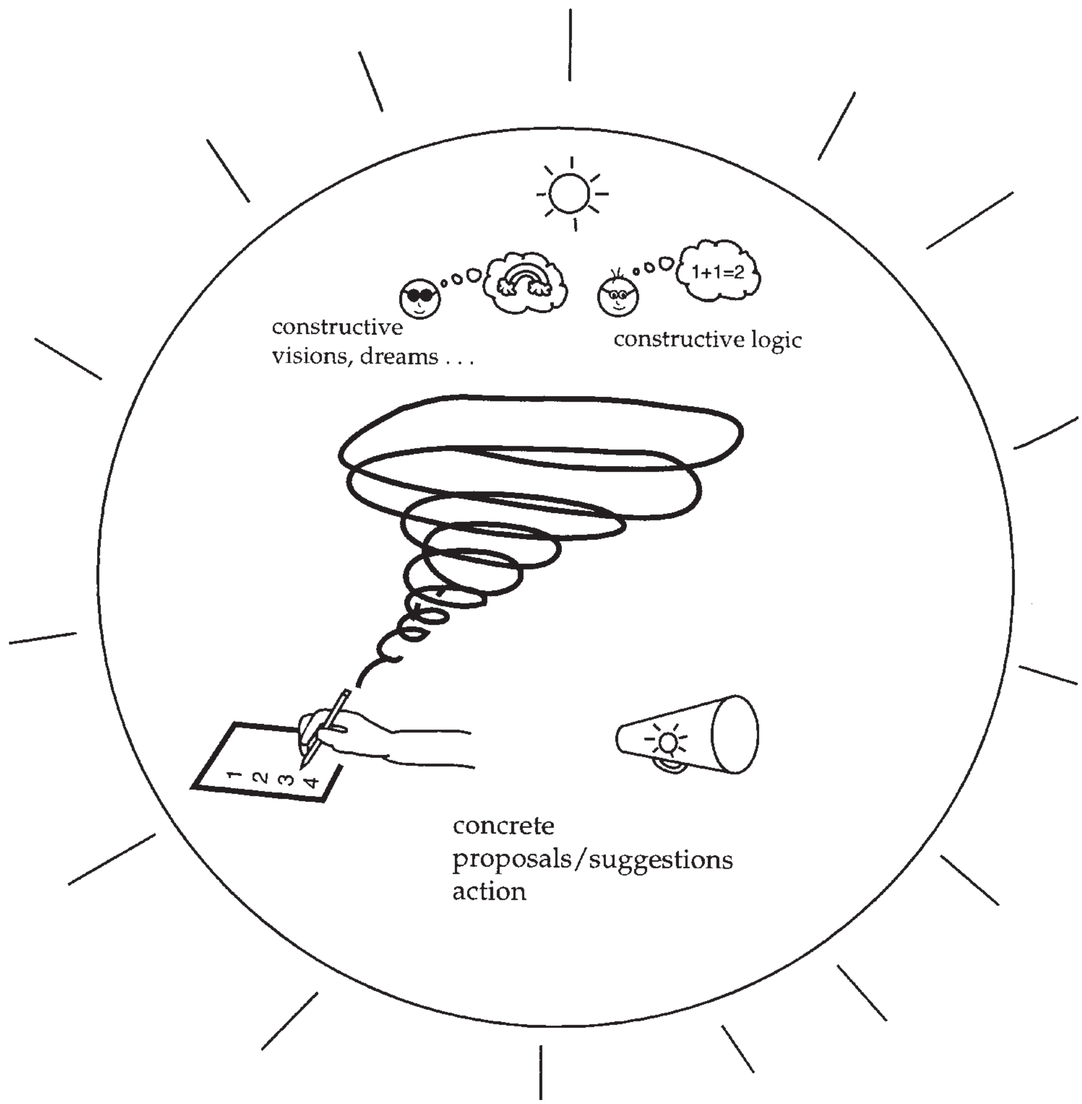
White Hat

Lab coat, facts, figures, probabilities, tightening-up questions, checking and re-checking, striving for objectivity, specifications of limits to knowledge.



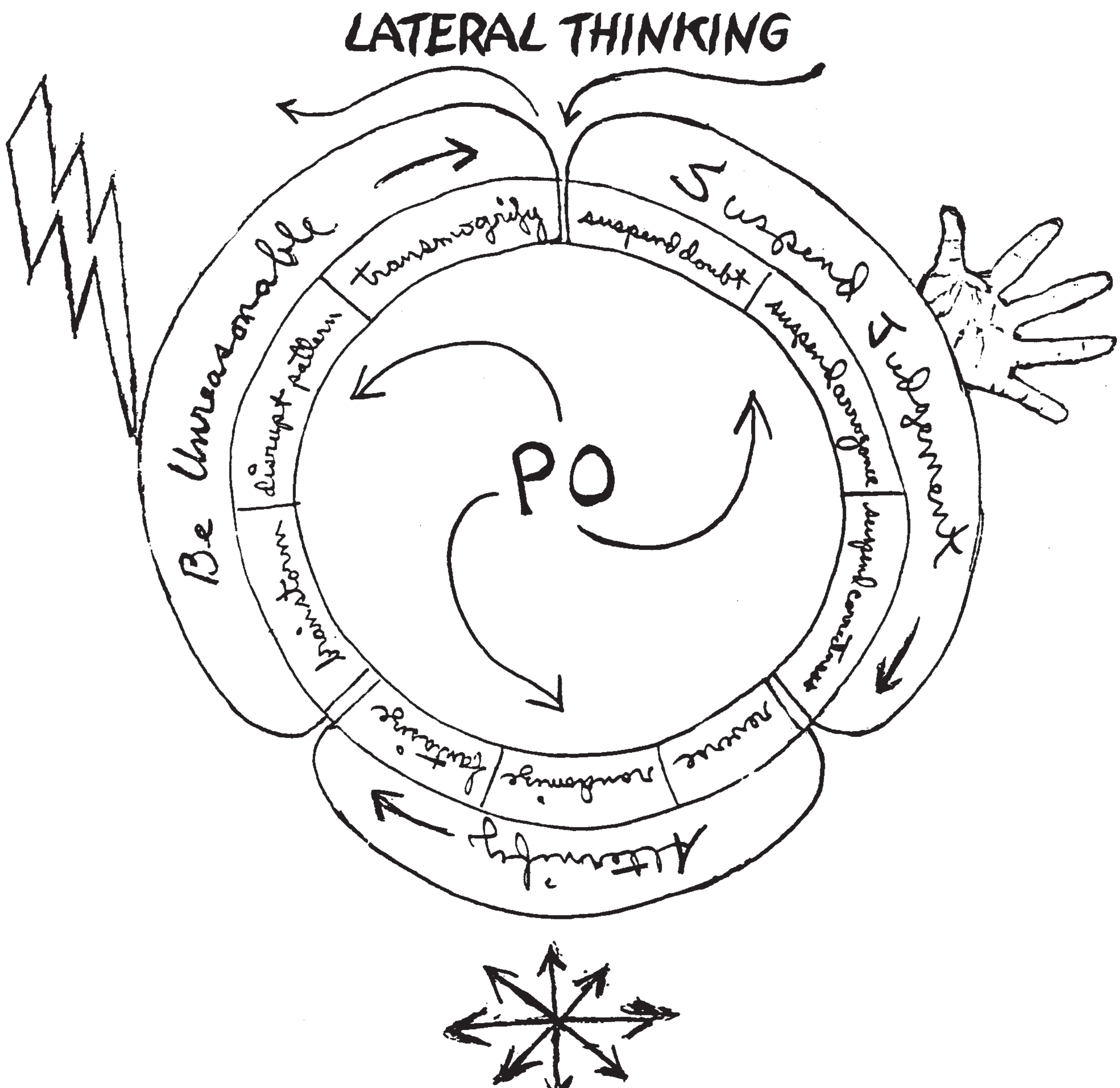
Yellow Hat

Sunshine, optimism, positive opportunity seeking, constructive logical assessment, concrete proposals. Sharing dreams, visions and hopes. Probing for value and benefit. Making things happen.



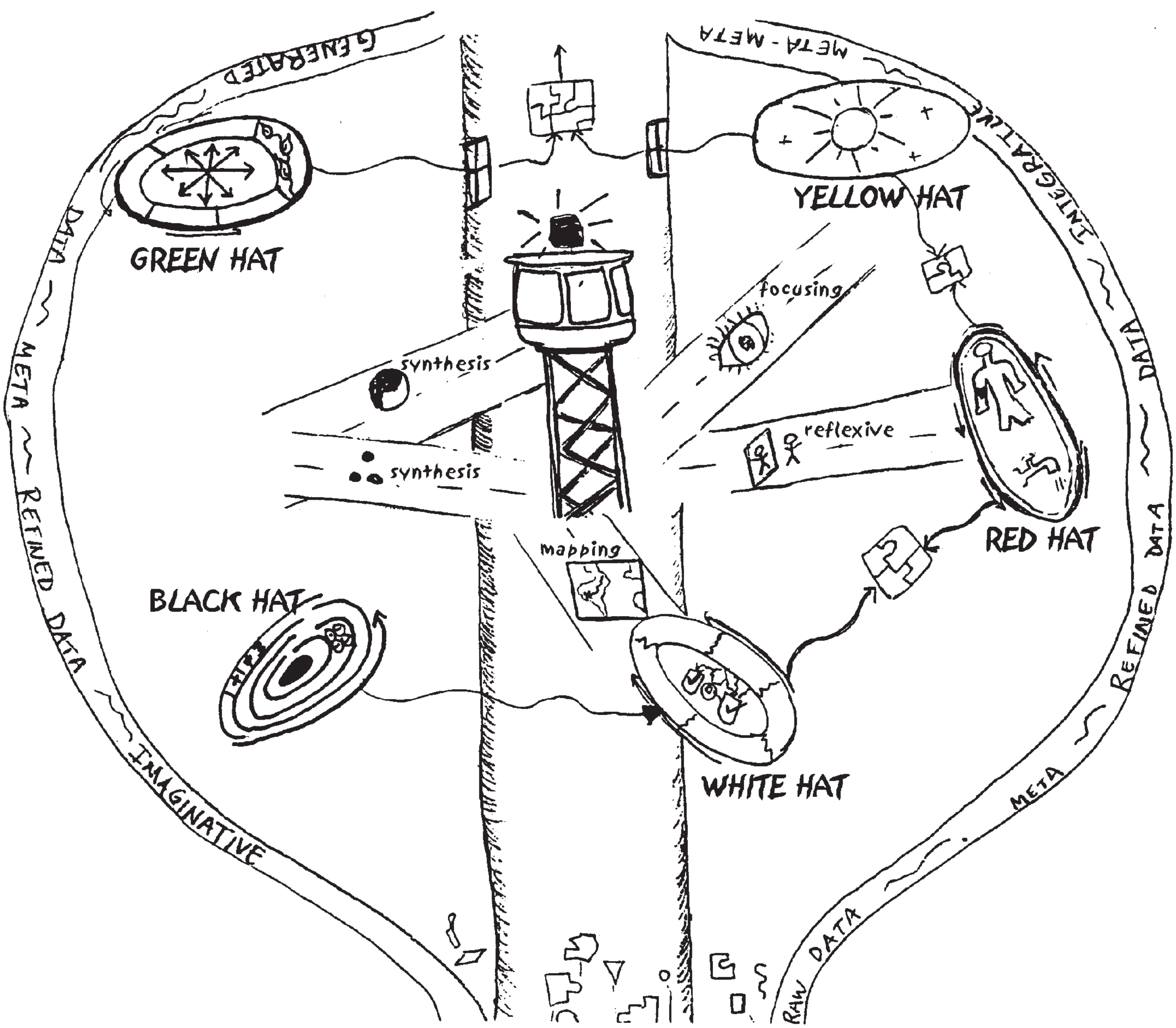
Green Hat

Fertile, creative, lateral thinking. Suspending critical judgement. Searching for alternatives. Going beyond the known, the obvious and the satisfactory. No justification needed. Provocative patterns of thought and movement of ideas are the goals; symbolized by the word *po*, the laxative of language, the opposite of *no.*



Blue Hat

Cool thinking from the control tower. Monitoring and coordinating. Organizing the thinking. Setting the focus. Defining the problems. Shaping the tasks. Providing summaries, overviews and conclusions. Thinking about thinking. Enforcing the discipline. Calling forth the hats.



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