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Is it possible to create an ecologically sustainable world order: the implications of hierarchy theory for human ecology

Arran E. Gare

Philosophy and Cultural Inquiry, Swinburne University, Hawthorn, Australia

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SUMMARY

Human ecology, it is argued, even when embracing recent developments in the natural sciences and granting a place to culture, tends to excessively pessimistic conclusions about the prospects for creating a sustainable world order. This is illustrated through a study of the work and assumptions of Richard Newbold Adams and Stephen Bunker. It is argued that embracing hierarchy theory, elaborated by Howard Pattee, T.F.H. Allen and others, enables human ecology to conceive humans both as part of nature and as cultural beings in a way that gives due regard to the ethical development of humanity. That is, ethical constraints need no longer be conceived of as 'unnatural'. Characterizing the nature of such constraints, which it is claimed emerge from 'the struggle for recognition', this argument is shown to justify some optimism about the future, and to give some idea of how society should be organized if ethical constraints, able to constrain humanity's relationship to the rest of nature, are to prevail.

INTRODUCTION: THE CENTRAL PROBLEM

Enormous demands have been made of human ecology by the global ecological crisis. Human ecology is the discipline charged with comprehending the relationship between the dynamics of societies and the rest of nature. It is the discipline through which both the environmental problems confronting us and the possibilities for overcoming them should be revealed. But human ecology has been somewhat disappointing. While the problems are recognized and documented by human ecologists, little direction for solving these problems has been provided. Typically, Kormondy and Brown concluded (1998, p. 433):

> Humans tend to optimize for the short term, rather than for the long term, in adapting to the environment. . . . [E]cological models of human behaviour appear to be most accurate when short-term gains are the focus of the models. This implies that behaviours that maximize resource output at the expense of ecosystem degradation will be adopted by human populations.

The remedy they offer is a new ethics based on a new attitude to nature:

> What is demanded is a rethinking of our place in nature, a rethinking of attitudes about the total environment – in the words Leopold (1949), the development of a new ethic for the land, and Potter (1971), the development of an ethic of survival. The Westerner's view is that land is an

Correspondence: Arran E. Gare, Philosophy and Cultural Inquiry, Swinburne University, PO Box 218, Hawthorn, VIC 3122, Australia. e-mail: agare@swin.edu.au

> adversary to be conquered, a servant to be exploited for human ends, a possession of rightful and eminent domain, and an entity of unlimited capacity. This view must give way to an ecological conscience, to a love, respect, admiration, and understanding for the total ecosystem of which we are a part; to an ethic that ensures the survival of the human species with quality, dignity, and integrity (p. 444).

These two statements exemplify a characteristic disjunction between the theories by which humans are analysed as a particular type of organism within nature and ethics. Although it is acknowledged by human ecologists that humans are cultural beings and by virtue of this have distinctive characteristics and dynamics which must be taken into account in understanding humans and their relationship to nature, it is not acknowledged that science and ethics, including human ecology and environmental ethics, are also part of culture and constitutive of the dynamics of societies.

My contention is that this reflects a basic theoretical deficiency in human ecology. Human ecology, charged with overcoming the division between the natural and the human sciences, has not kept up to date with theoretical advances in either the natural or the human sciences. In particular, human ecology has not embraced hierarchy theory, and has not come to grips with the most advanced efforts to understand the nature of culture. Here I will examine one of the most ambitious attempts to incorporate developments within the natural sciences into human ecology and to reformulate the human sciences accordingly, and through this to characterize the roots of global environmental destruction. This is the work of Richard Newbold Adams and Stephen Bunker, two theorists who have attempted to reformulate social theory through energetics. By revealing the theoretical deficiencies in their work and showing how these can be overcome through hierarchy theory, it will be shown how human ecology, reformulated on this basis, could play an essential role in creating an environmentally sustainable civilization.

THE ENERGETIC PERSPECTIVE OF RICHARD NEWBOLD ADAMS AND STEPHEN BUNKER

From the energetic perspective on human development proposed by Richard Newbold Adams (1975, 1988) and further elaborated by Stephen Bunker (1986), the future for humanity looks grim. There is an inherent tendency for humans to expand their capacity to exploit and transform the usable forms of energy within their environments. Such transformations involve the conversion of humanly useful forms of energy into humanly useless forms, but in this process energy is partially and temporarily conserved in useful energy forms which stimulate and facilitate production-enhancing modifications of the physical environment and increasingly complex social organization. The conservation of useful energy forms makes it possible to develop new and more powerful means of exploiting the usable energy in the environment and for some people to dominate and control other people to extend this exploitation. These developments are associated with the establishment of hierarchies of power and control, both within and between societies, that is, by class societies and by imperialism in its many forms, culminating in the present global system of capitalism. Such expansion will continue exponentially until humans undermine the conditions of their own existence or totally lose control of their own development.

What drives these developments? On the motivational level, the situation appears clear enough – the life situations of some people are improved by expanding the exploitation of nature and other people. In modern societies in particular, such people are not only those who have the power to appropriate the benefits from such expansion, but also those whose power is further increased by this expansion. In other words, developments in society which increase the exploitation of usable energy and the control of people to effect this exploitation continue because it benefits those who have the strategic capacity to implement decisions to pursue these developments. And such developments tend to increase the amount of usable energy they control, thereby further increasing their strategic power. It would appear that there is no escaping this logic. Leaving aside issues of efficiency of use of energy, or the proportion of energy devoted to expanding power to control people and nature, any community or society which attempts to preserve or establish an energetically less

voracious, less environmentally destructive form of life will thereby be less powerful. Eventually it will be overwhelmed by more aggressive societies which have chosen an energetically more voracious, more exploitative, more destructive, path. Can this logic be avoided?

ADAMS' THEORY OF HUMAN DEVELOPMENT

To answer the question posed in the title, we need to examine Adams' theory of society in more detail. His argument is that the evolution of humanity exemplifies general principles of energy dynamics of far from equilibrium thermodynamic systems (Adams, 1975, 1982, 1988). Human society is an example of an open system which, having available to it new sources of usable energy, creates new structures through the dissipation of this energy. Adams argues further that what is involved in the development of more complex structures of life can be explained by Lotka's principle of selective advantage, together with Margalef's (1980) principle that in interaction, larger structures tend to prevail over smaller structures. Lotka's principle is that '[i]n every instance considered, natural selection will so operate as to increase the total flux through the system, so long as there is present an unutilizable residue of matter and energy available' (Adams, 1988, p.36; Lotka, 1922, p. 148) As Lotka explained this:

> [S]o long as there is an abundant surplus of usable energy running 'to waste' over the sides of the water mill, so to speak, so long will a marked advantage be gained by any species that may develop talents to utilize this 'lost portion of the stream.' Such species will therefore, other things being equal, tend to grow in extent (numbers) and this growth will further increase the flux of energy through the system. (Adams, 1988, p. 36: Lotka, 1956, p. 357)

Adams argues that this principle complements the arguments of the ecologist Ramon Margalef that '[t]he biosphere is continually producing pieces of construction in the form of blocks or entities [or structures] that exist in a state of tension, in comparison with what we may consider as a background of greater fluidity and continuity' (Adams, 1988, p. 42; Margalef, 1980, p. 31), and that the size of these structures is important because it provides the opportunity for the greater production and storage of information. While information is defined here through the physical properties of systems, it is taken to include memory, prevision and consciousness. Margalef argues that in the relation between any two unlike structures, there will tend to be an unequal exchange of energy and information which always disproportionately benefits the larger structure. In short, 'in any interaction between organisms of different dimensions, with other conditions being equal, the larger organism has advantages' (Adams, 1988, p. 42; Margalef, 1980, p. 27).

Adams applies such ideas to humans. He proposes an 'energy' theory of power as 'the control that one actor, or party, or operating unit exercises over some set of energy forms or flows and, most specifically, over some set of energy forms or flows that constitute the meaningful environment of another actor' (Adams, 1975, p. 12). The more power an agent (individual or collective) has, the more it will be able to effect changes that will increase its power. As the economist and complexity theorist Brian Arthur would argue, social life is characterized by increasing returns – those agents which are successful will have the means to become even more successful in the struggle with other agents. Humans have the capacity to develop extra-somatic means of adaptation – tools, weapons, skills, knowledge, behaviour patterns, conceptions of themselves and their environments – which Adams identifies as 'culture'. The production, maintenance and even more, the development of 'culture' requires large amounts of usable energy, but then facilitates access to and exploitation of even greater amounts of usable energy and enables some people to control others and establish hierarchies of power.

Throughout history, humans have developed more complex integrative levels, from bands to tribes, to chiefdoms, to kingdoms, to empires, to nations and then to blocs of nations and, with each new integrative level, societies have become more differentiated. The development of hierarchies within societies has generated mutually amplifying co-evolutionary systems within these societies themselves. The most important systems in this regard have been the regulatory and working sectors. Co-evolution has

generated further specialist structures, mostly associated with the regulation of society and the means for this regulation (such as educational and research institutions). And so long as these emergent levels and specialist structures enable society to find new sources of usable energy and more effective means of exploiting both the environment and subordinate social structures, they can perpetuate the state which favours the survival of these more complex social structures.

Adams has used this scheme to characterize and analyse developments through the whole history of humanity and in every kind of society (Adams, 1976, part three). However, he has been particularly concerned with recent history, examining the rise of industrialism in Britain based on discoveries of new sources of energy, new triggers to release this energy and new forms of energy for extending, storing and controlling these flows of energy (Adams, 1982, 1988). He has also shown how these triggers were exported to the rest of the world and how these developments have been associated with the ensuing industrialization, associated with a constant expansion in the use of energy and with greater portions devoted to the regulatory sector. The consequences of such developments has been a population explosion (in which high energy societies with low birth rates interact with low energy societies with high birth rates to produce a self-expanding system), reduction in ecological and species variability, reduction in cultural variability at the global level, increased differentiation of levels of affluence (and poverty) and increasing energy flow and complexity (Adams, 1988, p. 238).

BUNKER'S DEVELOPMENT OF ADAMS' THEORY

Stephen Bunker (1986) has developed Adams' theories further to analyse the present global economic system, reformulating dependency theories and neo-Marxist theories of imperialism to show how peripheries of the world economy are dominated by the core zones. Focussing on the history of the Amazon basin, he has shown how extractive economies, exploiting natural resources to supply to the core zones, are impoverished as they 'develop', while the productive economies of the core zones, with economic development increase their power to dominate and exploit the peripheries. The more organized states or regulatory structures of semi-periphery regions, such as the Brazilian state bureaucracy, were shown to be vehicles through which core zones, by virtue of their power to dominate such states, have been able to intensify their exploitation of and extraction from the peripheries. As Bunker put it:

> The flow of energy from extractive to productive economies reduces the complexity and power of the first and increases complexity and power in the second. The actions and characteristics of modern states and their complex and costly bureaucracies accelerate these sequences. Modernization, as ideology, as bureaucratic structure and procedure, and as centralized control through complex regulatory organization, mediates and intensifies the socio-economic consequences of the interaction between global and regional systems. . . . The modern state is but one of the forms of social organization which draw on energy flows out of modes of extraction and which extend the dominance of energy-concentrating modes of production, both globally and within nations. . . . The differences between the internal dynamics of modes of extraction and of modes of production create unequal exchange not only in terms of the labour value incorporated into products but also through the direct appropriation of rapidly depleted or non-renewable natural resources. Extractive appropriation impoverishes the environment on which local populations depend both for their own reproduction and for the extraction of commodities for export (Bunker, 1985, p. 21f.).

Bunker went on to show in detail the destructive effect on the Amazon basin and its local inhabitants of the international economy and the Brazilian bureaucracy, showing how:

> Once the profit-maximizing logic of extraction for trade across regional ecosystems is introduced . . . price differentials between extractive commodities and the differential return to extractive labour stimulate concentrated exploitation of a limited number of resources at rates which disrupt both the regeneration of these resources and the biotic chains of co-evolved species and associated geological and hydrological regimes (Bunker, 1989, p. 47).

Bunker's study of the exploitation of Amazonia showed how the transferral of most of the usable energy in living and fossilised plants to a small part of the world is generating socially costly

hypercoherence and ecologically costly over-exploitation of natural resources. And as he pointed out, 'hypercoherence ultimately leads to ecological and social collapse as increasingly stratified systems undermine their own resource base. . . . The exchange relations which bind this system together depend on locally dominant groups to reorganize local modes of production and extraction in response to world demand, but the ultimate collapse will be global, not local. The continued impoverishment of peripheral regions finally damages the entire system' (Bunker, 1988, p. 253). In essence, Bunker provides cogent support for Adams 1975 diagnosis of the human predicament, that: 'The problem that confronts us is that human society has always been an expanding system, and there are implicit reasons for this in the nature of biology and culture. Yet it is clear that it cannot continue much longer as an expanding system, that it will have to move to some other kind of state or states' (Adams, 1975, p. 311).

IS THERE A SOLUTION?

After detailing the disastrous effects on Amazonia of its interaction with the global economy, Bunker concluded that the only way to prevent the environmental destruction of the peripheries is to radically revalue nature, labour and community and to create an egalitarian human society which sees itself as part of, rather than the master of, nature. What is required immediately are changes in the class structure of peripheral countries and efforts to reduce the interrelationships between peripheries and core zones, to allow the peripheries to develop their economies more autonomously: 'Ultimately, the need is to slow the flow of energy to the world center' (Bunker, p. 253).

However, if Adams' analyses are right, power to create such a future lies for the most part with the core zones, and within the core zones, with its dominant structures, the regulative sectors. It is these which control greater flows of energy and thereby have the power to control the energy forms and flows which constitute the meaningful environment of other agents of their own society and in the rest of the world. If their domination of peripheries generates a global ecological crisis, the members of these powerful structures will make sure that it is not they but those without power who will bear the cost. Adams concludes a discussion of this issue on a pessimistic note. After dismissing the possibility of controlling environmental destruction through a world government or by going back to an agrarian or hunter–gather form of life, he questions less radical approaches:

> [T]o assume that a 'religion' or 'widespread education' will produce an 'ethic' can be meaningful only if the level of energy of the society and the level of power in the system are appropriate for those devices. . . . Proposals for utopian futures need to consider not only the energy sources but also the power structure that will necessarily come into being from any such energy base and the administration and communication systems that can be supported by that level of energy conversion. It is perhaps, a little much to ask of man that, in order to survive, he cease to be human (Adams, 1975, p. 314f.).

In other words, ethical constraints are unnatural and any effort to impose such constraints is bound to fail for this reason. It is human nature to increase exploitation of nature and other people indefinitely until the conditions for humanity's continued existence are undermined or society has become so complex that it will be out of control.

Is this pessimistic conclusion justified? To see whether it is, we need to consider the validity of Adams' conceptual scheme and of the analysis of human history and modern society he and Bunker have offered, and then the validity of the conclusions drawn from this analysis. The idea that the move towards bigger and more powerful structures is inexorable is questioned by Adams himself, who notes that dinosaurs created very large forms but were replaced by other forms which individually used less energy. Elsewhere, Adams notes that where there is a constant source of energy, ecosystems often reach a final steady state of complexity and that organisms, particularly animals, only grow in complexity and size to a certain extent, and then stabilize. These instances suggest that Adams' analysis is too simple. Drawing on hierarchy theory and through it interpreting developments in cultural and social theory, I will argue that it is, both at a general level as an ecological theory, and specifically in its analysis of social dynamics.

DEVELOPMENTS IN ECOLOGICAL THEORY

What is left out by Adams and Bunker is hierarchy theory. Hierarchy theory originated in the work of Herbert Simon, but has been developed by a number of other thinkers, most importantly by Howard Pattee (1972). It was appropriated by ecology, first in Allen and Starr (1982), and a simple exposition of the basic ideas of hierarchy theory has been published recently by Ahl and Allen (1996). However, the most useful starting point for considering the implications of hierarchy theory for ecology is the work of O'Neill and his colleagues.

Reviewing the history of ecology, O'Neill *et al.* (1986) argue that two main strands have emerged within the discipline, the 'population–community approach' which focuses on biota and views ecosystems as networks of interacting populations, and the 'process–functionalist approach' which treats organisms and their physical environments as integral biogeochemical energetic systems. The extreme form of this takes energy flow and nutrient cycling to be more fundamental than the biotic entities performing the function. O'Neill *et al.* argue that these approaches are complementary and both are required to properly understand ecosystems.

The first advantage of acknowledging the separation of the two approaches is that the theoretical potential of each can be examined separately. The second advantage is that it is then possible to work out the relationship between the insights of the two approaches.

In examining the implication of far from equilibrium thermodynamics and hierarchy theory for ecology, O'Neill *et al.* 1986) show the inadequacy of simple theories of hierarchy formulated in terms of tangible components, identifiable independently of their participation in a system. These approaches overlook abiotic functional components and fail to acknowledge biotic components which are radically changed by their interactions and relationships within broader systems. Also inadequate are trophic levels, since it is difficult to unambiguously assign organisms to a particular trophic level. Following Simon and others, O'Neill *et al.* argued that to properly understand hierarchies it is necessary to identify different process rates, arguing that '[t]he structure imposed by differences in rates is sufficient to decompose a complex system into organizational levels and into discrete components within each level' (p. 76). Behaviour corresponding to higher levels occurs at slow rates, while lower levels are characterized by relatively fast rates. While some hierarchies are nested with higher levels being composed of and containing the lower levels, this need not be the case.

Systems can be further divided on the basis of rates into subsystems or 'holons', that is, wholes with a boundary or surface which, while being composed of parts, are themselves parts of larger wholes. Such holons can be interpreted as a special case of the relationship between processes of different rates. Within a holon there is a high frequency of interaction between components, while these components interact with components of other holons relatively infrequently. Tangible boundaries can be characterized by the sharp gradient of rates that occur as a boundary is crossed. These emerge naturally from differences in rate processes. As O'Neill *et al.* (1986) put it, 'structural boundaries represent one class of discontinuities and arise where especially steep gradients in several distinct rate processes converge' p. 89).

Showing how the development of such hierarchies are generated through the evolution of open, dissipative systems does not by itself account for what is involved in the formation of new hierarchical levels. O'Neill *et al.* (1986) argue (following Howard Pattee) that a new level involves 'self-simplification, precisely because the organization imposes a new system of constraints that both decrease the complexity of behaviour and ensure a new metastability that permits even further developments' (O'Neill *et al.*, p. 12). While the theory of dissipative structures explains how the flow of energy can create new and highly-ordered structures, hierarchy theory is required to analyse the stratified stability whereby highly ordered structures can persist to form 'building blocks' for still higher levels of organization.

By virtue of such structure, the kinds of interactions that can occur are limited. Holons operating at similar rates have the potential to interact because they are geared to the spatiotemporal dynamics of each other. But where there are hierarchical levels, relationships are

asymmetric in two ways. First, higher levels can affect lower-level holons but are relatively unresponsive to changes at the lower level. Second, while higher level processes constrain the behavioural flexibility of all lower-level processes, these lower levels are essential to the functioning and persistence of higher-level processes (Grene, 1969). Essentially, the higher level with its slow rate of activity acts as a constraint on the lower level with its rapid rate of activity, while the lower level is the condition of existence of the higher rate. For example, the leaves of a tree are affected by the tree's growth, but the hourly and daily fluctuations of the leaves associated with photosynthesis and respiration, which are relatively rapid in relation to the growth of the tree, do not register in this growth. At the same time, the leaves are constrained by the tree's structure (which limits their capacity to move) and functioning (which limits its nutrients) while the tree's growth is dependent on the activities within and of its leaves. A similar double asymmetric relationship exists between the individual organisms of an ecosystem and an ecosystem as a whole.

Previously it was noted that the hierarchical order defined by process rates, from functional components to the biosphere, do not correspond to the individuals organized into populations, guilds and communities, emphasised by the population–community approach to ecosystems. In fact individual organisms will occasionally be seen as parts of different structural levels. As O'Neill *et al.* (1986) observed, 'In the biotic observation set, the tree is a holon. In the functional observation set, tree leaves appear as a high-frequency entity that functions to fix carbon, while tree boles appear as a separate functional entity, combined with detritus, that function to retain and slowly cycle nutrients' (p. 190). Radical changes in species within an ecosystem are compatible with the system as a whole retaining its stability.

But this does not mean that the units identified by the population–community approach are of no significance. Populations also have a hierarchical structure paralleling the hierarchical structure of functions. Empirical studies of ecosystems indicate the existence of food webs containing an internal organization constraining competition, with species grouped into subsystems or modules. While not completely separate from each other, such modules form components of a hierarchical structure that in both analytical and simulation studies are shown to enhance ecosystem stability (O'Neill *et al.*, 1986, chapter 7).

That is, there is a dual hierarchy in ecosystems. Each hierarchy is a constraint for the other. Generally, when a system is released from one kind of constraint (for example, from a functional constraint after finding new sources of nutrients) it will next meet a constraint on the other hierarchy (for example, the resulting population explosion is likely to lead to an influx of predators or parasites).

Taking into account both the process–functional approach and the population–community approach, recognizing different spatial and temporal scales and the operation of constraints facilitates a more adequate grasp of ecosystem behaviour. At whatever scale is adopted, an ecosystem will appear homeorhetic; that is, it will tend to return to its trajectory of development after a perturbation. Such perturbations are by definition outside the system. But such perturbations can be incorporated into an ecosystem when at a higher level of organization some control over the abiotic environment is established which is uncontrolled at a lower level. For instance, forests control to some degree temperature, levels of humidity and even rainfall which are out of the control of individual organisms. Nutrient recycling, characteristic of rainforests, is also an example of incorporation. In this way abiotic elements, such as soils and climates, become incorporated into ecosystems.

In the resulting stabilized environment, species can be selected for their compatibility with other species rather than with the physical environment. Complexity can then increase as new species find new ways of exploiting an environment that is becoming more diverse. The process continues in positive feedback fashion, with the increasing stability and diversity of the environment allowing an increasing diversity of species.

Instability in ecosystems is associated with the breakdown of hierarchical organization. The propensity for this is inherent because ecosystems are characterized by positive feedback as well as negative feedback, and the effect of positive feedback is likely to overwhelm existing

constraints. In such circumstances, either a new set of constraints will form, or the system can degenerate, losing the ability to incorporate perturbations. In such ecosystems the slow rate processes will disappear. But hierarchical order and positive feedback can also give rise to saltatory evolution, that is, evolution in 'jumps'. Normally, the constraints of ecosystems are such that novelties introduced by genetic changes will be repressed by natural selection. But when a minor additional genetic change succeeds in breaking through a constraint, there is likely to be a rapid change in the hierarchical system with explosive adaptive radiation (O'Neill *et al.*, 1986, p. 175). No drastic alterations in the environment are required for this to occur.

THE LIMITATIONS OF ADAMS' ECOLOGY

Looked at from the perspective of such ideas, Adams' work cannot be dismissed as wrong, but it does appear to be limited and blind to some crucial features of ecosystem development. To begin with, his account of hierarchical ordering is defective. He has confused functional units associated with energy flows with tangible organizational levels, and then mistaken structural levels of ecosystems considered as dissipative systems with levels of organization of these organizational levels. When this confusion is avoided, the picture of evolution as an inexorable movement towards larger and more powerful structures which inevitably dominate and reduce to instruments less powerful structures, loses its plausibility, and the problems facing humanity must be partly at least reconceived.

As we have seen from the work of O'Neill *et al.* (1986), the higher levels of a dissipative structure are associated with slower rates. They act as constraints on lower levels not by reducing lower levels to instruments of the higher levels, but by limiting the possibilities open to the lower levels. In ecosystems, far from this being domination of the lower levels, such limitations enable external environmental factors to be incorporated to provide environments more favourable to the flourishing of life. The emergence of these higher-level processes with slower rates creates new environmental niches which provide the conditions for the emergence of new organisms, that is, processes characterized by faster rates. That is, there tends to be co-evolution of processes with slower and faster rates.

It is in this context that it is necessary to analyse the relationship between different organisms and levels of organization of organisms. What type of organisms there are, how they can behave and interact, what organizational levels they can form and how they evolve, is constrained by the emergent dynamics of the ecosystem; but at the same time these emergent dynamics are male possible and constrained by the nature of organisms. When this context is taken into account, it becomes clear that while Lotka's and Margalefs principles of selective advantage might operate, the competition that Lotka and Margalef, and then Adams, assumed, is highly constrained. To begin with, such competition only occurs with organisms (or groups of organisms) of much the same spatial and temporal level of organization. Leopards are in competition to some degree with lions, although even in this case their niches do not coincide; but scorpions, let alone a vast diversity of insects, bacteria and viruses, are not the least threatened by lions. What is more important is that all interactions, whether or symbiotic, predator–prey or a variety of more complex relations between these two extremes, are constrained within ecosystems (insofar as they are systems) to participate in a diversity of slower processes – the recycling of water, of carbon, stablilizing temperature and humidity, and so on. Such constraints (which of course can be broken – leading to the formation of new constraints or the disintegration of the ecosystem) usually involve constraints on the freedom of organisms to exploit or dominate other organisms. Just as in organisms (which can be regarded as highly integrated ecosystems (Depew and Weber, 1996, p. 474f.)), constraints between components limit and canalize interactions. As we have seen, ecosystems tend to develop a modular structure with much more limited interaction between organisms outside these modules. The breakdown of such constraints on components and their interaction is associated with positive feedback loops which can then overwhelm higher-level constraints. Such breakdown is equivalent to cancer in an organism which, having overwhelmed the constraints on the growth of component cells, eventually leads

to the death of the organism. The breakdown of constraints on particular species' capacity to exploit their environments within ecosystems is thermodynamically similar, and can lead to the destruction of the ecosystem.

Hierarchy theory is also important for understanding the unique characteristics of humans. Counter-intuitively, the power and higher levels of freedom characteristic of humans and human society is also a product of emergent constraints. As Howard Pattee pointed out:

> The constraints of the genetic code on ordinary chemistry make possible the diversity of living forms. At the next level, the additional constraints of genetic suppressors make possible the integrated development of functional organs and multicellular individuals. At the highest levels of control we know that legal constraints are necessary to establish a free society, and constraints of spelling and syntax are prerequisites for free expression of thought (Pattee, 1973, p. 73f.).

The evolution of humanity has been characterized by new social forms, each of which is associated with more constraints, and thereby new forms of freedom.

REDEFINITION OF THE PROBLEM

We can now see that the predicament of humanity is somewhat different than that portrayed by Adams – although not entirely. The growth of increasingly powerful and environmentally exploitative social structures cannot be portrayed as a simple extension of the evolutionary logic of dissipative systems. The situation is more complex. To begin with, the emergence of new hierarchical structures requires a specific theory, and each new level has distinctive characteristics which, to some extent, must be understood in its own terms. Humanity's relationship to the ecosystems of which it is part, particularly as this develops through history, is more complex than Adams' conceptual scheme is able to acknowledge. To begin with, advanced ecological theory provides a different perspective on the problematic nature of humanity's relationship to the ecosystems of which it is a part.

The core problem of humanity's relationship to ecosystems is not just that they have acquired ever new sources of usable energy and new forms of organization to grow exponentially until they have started to impoverish their environment. The problem is that throughout history humans have learnt to overcome one ecological constraint after another. To begin with, when with the emergence of agrarian societies humans were able to overcome the limits on their development provided by the flows of nutrients within their ecosystems, they frequently destroyed these ecosystems and salinated their land or created deserts, while the cities they created were invaded by disease-causing organisms which limited population growth. That is, the overthrow of one set of ecological constraints enabled rapid population growth and the differentiation and expansion of society, but this was then met by new constraints which limited population growth. Subsequent to this, expansive human societies developed the means to extend their exploitation over far greater areas, so that the destruction of local ecosystems no longer served as a constraint, although such civilizations were still frequently ravaged by epidemics. Later, humans developed means to control diseases. Later still they developed the means to exploit fossil fuels and to produce machinery, freeing them from the energy constraints of all ecosystems, at least in the short term. One such constraint after another has been overcome, until we have reached our present stage. Now the constraints of local ecosystems throughout the world, but particularly in the peripheries where lie most of the world's tropical forests, are being destroyed, and we are pushing towards the constraints of the global ecosystem, the biosphere. For example, greenhouse gases, with their effect being exacerbated by the destruction of organisms and regional ecosystems which contributed to regulating gases in the atmosphere (for example, the Amazon rain forest) could generate positive feedback loops leading to a runaway increase in global temperature. This appears likely given the studies of the most advanced computer modelling of changing weather patterns at the Hadley Centre for Climate Prediction and Research in Britain (Brown, 1998, p. 1). Such changes are unlikely to damage the biosphere as a global ecological system. This system will maintain and regenerate itself by undermining the conditions for the processes which have been damaging its self-regulating processes – that is, those processes associated with humanity's flourishing.

THE CULTURAL DYNAMICS OF SOCIETIES

If the theory of dissipative structures as elaborated by Adams is only a one-sided account of the dynamics of ecosystems, clearly human development as portrayed by Adams cannot be accounted for as an extension of the principles he claims govern the evolution of ecosystems generally. But this does not mean that Adams' (and Bunker's) characterizations of these dynamics are wrong where human societies are concerned. Energetic factors should be recognized as an important component in human history, and it could he that Adams has shown that humanity, because of its very nature, will inevitably follow a path of development which is an evolutionary dead-end. However, the corrected version of the energetics of ecosystems, incorporating hierarchy theory, by itself suggests that there is a dimension to social dynamics that has been ignored by Adams. And there are features of humans unacknowledged by Adams which provide a different perspective on human history. These two dimensions when conjoined suggest different possibilities for the future than Adams has countenanced. They suggest that the imminent global ecological crisis could be more serious than Adams has realized but, at the same time, that there is more reason for hope that the path of development of humanity could be changed.

The first new dimension to social dynamics, suggested by the energetics of ecosystems, is that societies could generate emergent hierarchical levels characterized by slower rates of change, able to constrain constituents to maintain more salubrious environments. The most important hierarchies to identify then are not the integrative levels from families to blocs of nations, but slowly reproducing and developing processes that we would normally take so much for granted that we would be unaware of them. Like the constraints associated with ecosystem dynamics, such constraints would be facilitative constraints, stabilizing the human environment and making possible faster rate processes.

This way of conceptualizing emergent hierarchies concurs with the ideas of the French historian, Fernand Braudel, who argued for a history with multiple rivers of time. As he put it:

> History accepts and discovers multidimensional explanations, reaching as it were, vertically from one temporal plane to another. And on every plane there are also horizontal relations and connections . . . Certain structures live on for so long that they become stable elements for an indefinite number of generations: they encumber history, they impede and thus control its flow. Others crumble away faster. But all operate simultaneously as a support and an obstacle (Braudel, 1972, p. 16f.).

Braudel attempted to write history by taking geography as the enduring structure within which other historical events had to be situated. This fits in neatly with an ecological approach to history and it is only a short step from there to incorporating other dimensions of ecosystems into history. But what are even more fundamental and what changes at an even slower rate are the defining features of humans, that humans are cultural beings. Somewhat faster rate processes are the defining mentalities of the specific human cultures which have emerged through history. My contention is that it is culture which functions as the human specific hierarchical constraint.

This is the second dimension of social dynamics. It is by virtue of culture that humans are able to create the complex forms of organizations and productive processes they have, and to become self-reflexive individuals capable of questioning the cultural heritage which formed them. Adams describes culture as 'the association that a collectivity of nervous system activities has with other things' (Adams, 1988, p. 88), and characterizes it as information retention made possible through a continuing process of reproduction between human nervous systems on the one hand and extrasomatic forms on the other. He goes on to argue that culture 'lies not in the separation of the human from the nonhuman but in the separation and recombination of the mental and energetic into unified symbolic structures. It is the arbitrary unification that is central to the operation of culture, and it is in the tenuousness of that unification that the constant potential and dynamic for cultural change takes place' (p. 90). This suggests a creative effort by Adams to describe culture in naturalistic terms while attempting to do justice to what makes human creativity possible. While Adams is right to see all cultural processes as energetic processes involving transformations of useful energy, either in people's brains or in their activities and cultural products, and he is right to see culture as responsible for the changing nature of human relationships and organizations and

productive processes, he has not done justice to the complexity of human culture. He has taken for granted that culture is only an aspect of human efforts to control their environments, whether this be the natural world or other people; that is, that it is only an instrument for controlling the world.

But according to the notion of culture which has developed from the pioneering work of Herder and Hegel, controlling the world through labour mediated by tools is only one of three fundamentally different, if interrelated dimensions (or dialectics) of culture (Hegel, 1979, pp. 205–53; Habermas, 1974; Gare, 1996; Honneth, 1996). Culture consists also of the struggle for recognition mediated by ethical notions through which people gain an identity, and the struggle for representation or orientation mediated by language and other sign systems through which people define their place in the world and make sense of their lives. These latter two dialectical patterns are at least as important as the dialectic of labour in human history. It is through the ability of humans to achieve a reciprocity of recognition and to establish their identities through this that complex forms of cooperative organization and enduring institutions are possible, and because such identities require reciprocal recognition, there has been an impetus through history for the recognition to become more adequate. That is, the dialectic of recognition has engendered the quest for and provided the impetus to achieve justice, and the advance of justice has made possible more complex forms of human enterprise. Human history is made possible by, and consists of, the interweaving of all three cultural processes, and through this interweaving, cultures have generated forms with their own logic (socio-economic formations, discursive formations, cultural fields, institutions and organizations ranging from the family to states and global enterprises) which endure and constrain these cultural processes, facilitating and sometimes undermining their further development.

Could the struggle for recognition and the quest for justice which has issued from it, supported by the struggle for representation or orientation and the wisdom which has issued from this struggle, provide the constraints on human interactions with nature and on human relationships which could divert humans from their present destructive path of development? This would appear highly unlikely if such constraints were conceived of as merely moral constraints. As Ulrich Beck noted, morality in the face of the global ecological crisis is 'like a bicycle brake on an international jet' (Beck, 1992, p. 106). But if we could accept some modified Hegelian view of history in which the history of humanity is characterized as a slow process of evolving civilizations, creating institutions which, despite a number of reverses, have gradually extended recognition of the significance and potentialities of increasing numbers of people in the organization of society and in everyday practice, there might be more grounds for hope (Hegel, 1956). Have we now reached a stage where it is possible to develop a global civilization with global institutions able to constrain people to properly recognize in the way they live not only every living person, community and culture throughout the world, but also people of the future (and of the past) and all other forms of life, including ecosystems?

To justify such optimism it is necessary to revise Hegel's characterization of history, not only to extend his political philosophy beyond the nation state and to grant a place to critical and creative thinking and action to envisage and realize such a feature, but also to avoid his Eurocentricism, to incorporate Marx's analysis of socio-economic formations, class relations and the inner dynamics of capitalism, and to take into account how the world has developed since Marx wrote – that is, how capitalism and industrialism have spread around the globe and how Eastern European and Chinese communism have failed as an alternative to it. More importantly, it is necessary to reformulate this view of history on naturalistic foundations, reformulating science on the basis of an anti-mechanistic conception of physical existence so that humans as creative social agents can be made sense of in naturalistic terms. My contention is that all this is possible. It involves carrying through the nascent revolution in science identified by Ilya Prigogine to create a new alliance between science and the humanities and 'humanistic' social sciences (Prigogine, 1980). The development of human (or social) ecology is central to this revolution. With this scientific revolution it becomes possible to understand the ethical development of humanity as the kind of

constraint which could limit the present environmentally destructive trajectory of civilization, and for it to successfully function as such a constraint. This could then provide the story of human development which could orient people for the struggle to create a new world order incorporating these ethical constraints.

PREVAILING OVER THE PREDATORS

This brings us back to our starting point. The question we should now be in a position to begin to answer is: If power derives from increasing control over energy triggers and flows, how can those attempting to reduce environmental destruction and who constrict their use of usuable energy survive and prevail over those who exploit the environment and other people to the destructive maximum? And what is being suggested is that the constraints associated with the evolution of ethical organization of societies which could limit the exploitation of energy and people and thereby environmental destruction, a form of evolution which in the past has been best understood by social and ethical philosophers influenced by Hegel, can themselves be seen in thermodynamic terms as an emergent level of dissipative structures. These constraints are analogous to the constraints which emerge in ecosystems to both stabilize and enrich them, or in the epigenesis and self-organization of animals, which to an even greater extent constrain the interaction between their components and between the organism as a whole and its environment, eventually limiting how much it can grow. What is added to neo-Hegelian social philosophy by seeing it in this way?

To begin with, the development of such constraints are themselves energetic phenomena and require that the development of society should involve directing energy to the development and maintenance of these constraints, constraints which must prevent developments which would overwhelm them. It is necessary to understand this in order to work out the conditions necessary to achieve and maintain these constraints. We can see from ecological theory that such constraints must include constraints on the interactions between various parts of the system as a whole. An ecosystem is stable when its food webs are articulated so that different parts are largely insulated from each other, and interactions are even more constrained within organisms. It is such constraints which prevent the kind of positive feedback loops which destroy the constraints which reproduce the system. When such constraints break down, the very existence of the system is under threat. Goats, which eat nearly all vegetation, when introduced into ecosystems without goat predators or diseases, are likely to destroy these ecosystems, and where the constraints on component cells and organs of an animal break down, we have cancers. We now have a global human society in which its most powerful structures have dissolved most of the constraints on human interaction between societies and with the environment, allowing for the emergence and growth of immensely powerful regulative sectors based in the core zones of the world economy, undermining further these constraints. If the global ethical order is to prevail over such cancerous growths, which now threaten to destroy the conditions of humanity's existence, it will be necessary to maintain and foster this ethical order. It will be necessary to maintain the autonomy of cultural, scientific and legal/political fields incorporating and sustaining the slow processes of humanity's cultural development from the economic processes which they should be constraining, and to do this it will be necessary to decentralize political power and insulate from each other as much as possible the economies of different parts of the world. And within each of these differentiated economies, there should again be as much decentralization as possible. If humanity suffers from the feedback loops generated by the interaction between the regulative and productive sectors of society, then it is also necessary to constrain these interactions to eliminate such feedback loops. That is, it is necessary to develop or organizations in which the differentiations between organizers and the organized are, as much as is practically possible, overcome.

How then does one survive among the predators? The answer would appear to be that it is necessary to act simultaneously, globally and locally. There is no future in taking on the present world system in isolation, either as an individual, a group, a community, a nation or even a bloc of nations. It is necessary to struggle as part of a

global environmental movement working towards a global culture with a commitment to global justice. But to make justice prevail it is necessary to struggle for organized economic and political decentralization, autonomy and self-reliance. The most likely structure to succeed, I believe, would be one which had multiple levels of ordered decentralization – that is, an international order working to minimize economic interaction between blocs of nations, blocs of nations upholding such organized decentralization internationally while limiting economic interaction between nations, nations fighting for this decentralization in turn while minimizing economic interaction between their regions, localizing as much as possible economic interaction within cities and local regions – which should in turn struggle for, and to, maintain such localization (Gare, 1996, chapter 12). Those working for the future of humanity need to struggle at all levels, including globally, uniting against those structures and organizations absorbing resources beyond their own territories and using other people, organizations and structures as instruments for this. It is also necessary to unite globally against the intermediaries or collaborators with such structures and organizations. Essentially, this supports the suggestions of Stephen Bunker on the basis of his study of the Amazon, but provides some direction and more detail on how his suggestions might be acted upon.

While organized decentralization could be the kind of ethico-political and economic order which could constrain humanity to preserve itself, it is an ethical choice to work towards such a goal. It is possible that those who choose to work towards this goal will fail; but the logic of non-linear thermodynamics suggests that the efforts of one individual could also be the deciding factor which leads to the success of the environmental movement. In *Order Out Of Chaos,* Ilya Prigogine and Isabelle Stengers remarked: 'It is quite remarkable that we are at the moment both of profound change in the scientific concept of nature and the structure of human society as a result of the demographic explosion. As a result, there is a need for new relations between man and nature and between man and man' (1986, p.312). They then went on to point out that the ideas in the physical sciences expounded by them, the ideas of instability and fluctuation in a world of processes, were also relevant to the social world. They concluded:

> This leads both to hope and a threat: hope, since even small fluctuations may grow and change the overall structure. As a result, individual activity is not doomed to insignificance. On the other hand, this is also a threat, since in our universe the security of stable, permanent rules seems gone forever. We are living in a dangerous and uncertain world which inspires no blind confidence . . . (p. 313).

Developments in non-linear non-equilibrium thermodynamics, granting a place to hierarchical organization, support rather than undermine those who believe it is worth struggling to create an environmentally sustainable civilization. It is up to each person to decide what part they are going to play in the coming struggle.

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