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ENTROPY AS ROOT METAPHOR

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ENTROPY AS ROOT METAPHOR

by

Eric Zencey

A Dissertation submitted to the Faculty of Claremont Graduate School in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate Faculty of Government.

Claremont

1985

Approved by:

J R Rodman

John Rodman

We, the undersigned, certify that we have read this dissertation and approve it as adequate in scope and quality for the degree of Doctor of Philosophy.

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ABSTRACT OF THE DISSERTATION

Entropy as Root Metaphor

by

Eric Zencey

Claremont, California: 1985

Metaphors establish connection. Root metaphors--patterns of relational imagery in the language and thought of a culture, in which a diverse group of tenors are related to a single indentifiable class of vehicles--play an important role in organizing our thought, and in bringing a coherence to our vision of the world. This is a political function; root metaphors, as philosopher Stephen Pepper discusses them, are most often found in the works of philosophers remembered as political philosophers.

The second law of thermodynamics--the law of entropy--holds that in any spontaneous process, usable energy becomes unusable energy. It also suggests that improbable order must succumb, through time, to more probable chaos. The law of entropy has enjoyed a popularity as

metaphor unusual for such physics esoterica. In the works of Brooks Adams, Henry Adams, Nicholas Georgescu-Roegen, and Thomas Pynchon, the idea of entropy appears as the fundamental, organizing idea for (respectively) an economic interpretation of history, a philosophy of history, an ecologically enlightened economic theory, and an encyclopedic novel that apotheosizes modern culture. Analysis of how the entropy metaphor is manifest in the works of these thinkers allows us to judge the strengths and weaknesses of entropy as root metaphor. Analysis of its contemporary popularity affords insight into the politics of the day. Ultimately, the entropy root metaphor serves as the foundation of a refurbished "generating substance" world hypothesis, but the root metaphor itself remains equivocal on the important issue of centralized versus decentralized political organization.

Acknowledgments

It is a rare work that is truly the product of a single mind. It is customary for authors of this sort of work to acknowledge that, and I do so here: I truly could not have produced this document without the help, guidance, and support of others. I owe to my dissertation committee a large measure of thanks for their patient forbearance (they have, I am certain, had just about enough of entropy by now) and their helpful comments. I would also like to thank Joseph Slade and the other organizers of and participants in the Conference on Science, Literature and Technology at Brooklyn College, at which I presented some of these ideas in rough form, and especially my panel colleagues on "The Metaphoric Allure of Modern Physics" for their provocative contributions; I only wish we had had enough time to share comments after the presentations. And to all my friends and colleagues who have, for several years now, kept an eye out for references to the idea of entropy in their readings, thanks.

My colleagues on the faculty and in the administration of Goddard College deserve thanks for the understanding with which they accepted this dissertation as my excuse for not serving on yet another committee; I know they look forward to its completion as keenly as do I. The assistance I received from Goddard, both moral and material, was invaluable. I want especially to thank Gary Welke and Ravi Nielsen for holding off the sale of the old OS 6 until I had completed a draft and could print it out.

I want especially to thank the Registrar at Claremont Graduate School, Betty Hagelbarger, for taking a special and personal interest in my case. The wheels of academic bureaucracy grind exceedingly slow in the summer, and without her willingness to marshall the appropriate documents from desk to desk I think the whole process of trying to meet institutional requirements at long distance would have been a great deal more frustrating.

I want to thank my parents, and especially my mother, for the moral and financial support they gave me through this difficult time in my life. I have tried to follow my mother's advice to "for god's sake, write it in English that an intelligent person can understand;" I hope she will forgive my occasional lapses into "dissertationese."

Finally, as you can well imagine, there aren't that many people in central Vermont with whom one can talk, to good purpose, about entropy. It has been my good fortune to know two. Frank Kalinowski read various drafts of this dissertation and provided helpful comments and criticism. To the other person, Kathryn Davis, I owe the largest measure of thanks. Without her confidence, her intellectual stimulation, and her constant support, I am certain that my energies would have simply dissipated.

It is also customary for authors, having acknowledged the contributions of others, to absolve those others of any complicity in whatever errors of fact or argument, whatever lapses in style or felicity of phrasing, that the work contains. I wonder why this should be so. It seems to me that such assymetry of responsibility is especially inappropriate in a dissertation, where final judgment on some matters, and hence ultimate responsibility, is not reserved to the author. I would also like to think that I am not such a dullard that a sound argument would not convince me of the error of my ways. I invite the reader, therefore, to find all of us who have had a hand in the form

and content of this work responsible for its strengths and its weaknesses.

I offer one final thought on acknowledgments: it is a peculiar artifact of the oppression of women in our society that the acknowledgments pages of most scholarly works are filled with men's names, listed in full, complete with titles. Until lately the only women's names one was likely to see were first names, those of the secretaries and drudges who typed the manuscript. I am pleased to be able to break with that particular tradition by pointing out that I did all of the typing myself.

East Calais
July 1985

for Daphne, and change...

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PROLOGUE: RANDOM NOTES ON ENTROPY

"...I have been present at gatherings of people who, by standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is about the scientific equivalent of: Have you read a work of Shakespeare's?"

C. P. Snow

"Entropy is a word which carries a large historical freight of good physics, profound paradox, dubious analogies, and flights of metaphysical fantasy."

Jeremy Campbell

"What do I miss, as a human being, if I have never heard of the Second Law of Thermodynamics? The answer is: Nothing. And what do I miss by not knowing Shakespeare? Unless I get my understanding from another source, I simply miss my life."

E. F. Schumacher

"There is really nothing more pathetic than to have an economist or a retired engineer try to force analogies between the concepts of physics and the concepts of economics. How many dreary papers I have had to referee in which the author is looking for something which corresponds to entropy...."

Paul Samuelson

"Thermodynamics is at bottom a physics of economic value...and the Entropy Law is the most economic in nature of all natural laws."

Nicholas Georgescu-Roegen

"Classical thermodynamics...is the only physical theory of universal content concerning which I am convinced that, within the framework of applicability of its basic concepts, it will never be overthrown."

Albert Einstein

"The quality which uniquely meets the natural requirements that one sets up for 'information' turns out to be exactly that which is known in thermodynamics as <u>entropy</u>."

Warren Weaver

"Information represents negative entropy."

Norbert Weiner

"'Value' means 'generalized negative entropy.'"

Leon Brillouin

"It is at least a useful first approximation of the problem of moral value to suppose that the highest test of a value is whether it performs an entropic or an anti-entropic function in society."

Kenneth Boulding

"Creativity: A Definition Based on the Concept of Negentropy"--title of an article by Jerzy Hubert in <u>Dialectics and Humanism</u>, Spring, 1978.

"There is no logical necessity for the existence of a unique direction for total time; whether there is only one time direction, or whether time directions alternate, depends on the shape of the entropy curve plotted by the universe."

Hans Reichenbach

"[Entropy is] time's arrow."

A. S. Eddington

"The second law of thermodynamics [is] the law of random, ravage, rust, and rot."

Herman Daly

I am a sleepless
Slowfaring eater
Maker of rust and rot
In your bastioned fastenings,
Caissons deep.

I am the Law
Older than you
And your builders proud.
I am deaf
In all days
Whether you
Say "Yes" or "No."

I am the crumbler: tomorrow.

Robert Frost

"...The conclusion is that total disorder provides a maximum of information; and since information is measured by order, a maximum of order is conveyed by a maximum of disorder. Obviously, this is a Babylonian muddle. Somebody or something has confounded our language."

Rudolf Arnheim

"Philosophical problems arise when language goes on holiday."

Ludwig Wittgenstein

"Modern philosophy is, as I maintain, wrecked on the Second Law of Thermodynamics; it is no wonder that it finds the situation intolerable, and wriggles piteously to escape from its toils."

William Ralph Inge

"All kinds of private metaphysics and theology have grown like weeds in the garden of thermodynamics."

Erwin N. Hiebert

"All of housework is a battle against entropy....Our society, up until a few years ago, had decided that the eternal struggle against disorder was women's work and that the possessors of two X chromosomes were to be consigned Sisyphus-like to the unending task of countering a law of nature."

Harold J. Morowitz

"Is science itself [in the form of the second law] driving us back to the traditional Christian doctrine that God created the world out of nothing?"

William Ralph Inge

"I am reluctant to hitch the wagon of faith to the shooting star of scientific fashion. For all we know, relativity and the quantum theory and entropy will one day join their predecessors in the limbo of discarded scientific fads."

Arnold Lunn

"Lay not up for yourselves treasures upon the earth, where moth and rust doth corrupt...."

Matthew, 6:19

"Die Entropie der Welt strebt einem Maximum zu."

Rudolf Clausius

"To say that the entropy of the universe tends to a maximum is simply to say that the universe is passing from an interesting, useful, and significant state, to an uninteresting, useless, and meaningless state."

Morton Mott-Smith

Then star nor sun shall waken
    Nor any change of light:
Nor sound of waters shaken,
    Nor any sound or sight:
Nor wintry leaves nor vernal,
    Nor days nor things diurnal
Only the sleep eternal
    In an eternal night.

Swinburne

"The development of the first [atomic] bomb shows that if something will be done in the U.S.A., very soon it will be done in our country, too. As a rule my point of view is that the arms race is like a piece of iron. If you heat one end of it, very soon the other end will be the same temperature. That's a law of thermodynamics. You may be first, but after a while there will be equality again--but at a very high temperature. It is impossible to violate equality."

M. A. Markov

"The prestige of entropy as an organizing idea has risen.... Does it advance upon us along with the disintegration which it indicates?"

C. C. Gillispie

"The physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback."

Norbert Wiener

"One hears it often said that in this world everything is a circuit. While in one place and at one time changes take place in one particular direction, in another place and at another time changes go on in the opposite direction; so that the same conditions constantly recur, and in the long run the state of the world remains unchanged. Consequently, it is said, the world may go on in the same way forever....

The second fundamental theory of the mechanical theory of heat contradicts this view most distinctly...in all the phenomena of nature the total entropy must be ever on the increase."

Rudolf Clausius

This is the way the world ends
This is the way the world ends
This is the way the world ends
Not with a bang but a whimper.

T. S. Eliot

"The reader must not be discouraged if he [sic] does not yet clearly understand what entropy is. Nobody else did at this point...."

Morton Mott-Smith

Chapter One

INTRODUCTION

"There can be no 'innocent' art...." -- Wayne C. Booth[1]

In one of its more accessible guises, the second law of thermodynamics -- the law of entropy -- holds that energy spontaneously degrades from more useful to less useful forms, even if it accomplishes no work in the process, and that in any transformation of energy (such as those by which we turn the energy of coal into electricity, and thence into heat, or light, or motion) some part of the energy is irretrievably lost to us. The energy does not disappear (as the first law of thermodynamics tells us, matter and energy are neither created nor destroyed, only transformed). In an entropic process, what is at first "free" energy ("free" in the sense of available, ready to accomplish work) becomes "bound" energy (energy that, like the enormous amount of heat energy contained in the ocean, cannot be used to accomplish work[2]). In addition to this fairly accessible interpretation of the law of entropy there are others: corrolaries that reach to fundamental issues of order and disorder, of probability, of time, and of the nature of all change, all transformation. For the law of entropy is also a law of probability, holding that in any spontaneous transformation, improbable order succumbs to more probable chaos.

A root metaphor can be described as a metaphor that is used to interpret experience across a broad range of phenomena. We owe the term to philosopher Stephen Pepper, who divined four distinct root metaphors in the philosophies of the western tradition.[3] Pepper argued that these root metaphors exist at the very foundations of our philosophies; each shapes our perception and thought in a characteristic way, each forms the basis of a distinctive tradition of philosphy.

Pepper's concept is perhaps best understood through contrasting example: mechanism and organicism are two competing, mutually exclusive root metaphors, each of which can be used to explain a range of diverse phenomena. Human society, for instance, can be seen as being "like a machine" or "like an organism" -- though the use of the word "like" here suggests a degree of explicit comparison that is not usually characteristic of metaphors. (We will have more to say on how metaphors and root metaphors come into being in the next chapter.) The mechanist does not set out to model human society after a machine, but instead implicitly assumes that modes of understanding appropriately applied to machines and mechanical systems will yield similar understanding when applied to social "systems". While the mechanist may evince a concern for causal relationships in society, and is drawn to looking at how various parts perform in concert to produce the activity of the whole, the organicist is led to focus on growth and the way the part is given meaning by the whole. As Stephen Salkever notes of the tension between interest group Liberalism and participatory Liberalism,[4] the partisans of the two camps often seem to be talking past one another: their rhetorics employ the same vocabulary, but attach different connotations to such central words as "politics", "freedom," "interest," "community," etc. Salkever's distinction is traceable, I think, to these two root metaphors. Within the interest-group tradition, politics is a mechanical balancing of forces and factions, the "authoritative allocation of scarce values." Within the participatory tradition, politics is the forum wherein individuals give voice to, and attempt to shape, the moral life of their community -- and achieve salvation or wholeness by doing so. Because they entail different definitions of the very purpose and matter of politics, it is impossible to view society simultaneously through the lenses of these two visions, these two root metaphors.

The work before you is a broad-ranging inquiry into the manner in which the idea of entropy has been used as a root metaphor, and the strengths and weaknesses of the various world visions that the idea of entropy suggests. In many fields of human inquiry -- in economics, politics, and history, in biology and ecology, in cosmology, astronomy, physics, and ontology, in aesthetic philosophy and ethics, to name a few -- the idea of entropy has been used as an organizing principle, an idea in and through which diverse thinkers have attempted to render our experience coherent and comprehensible. The law of entropy is "the most metaphysical of the laws of physics," "difficult to picture," "imperfectly understood even by some physicists," and "much harder for the mind to grasp than the first" law of thermodynamics.[5] There is some irony, then, in our turning to such a slippery idea in an effort to make the world more intelligible. And yet it is because the idea is so slippery that it has found such widespread use. Much like an earlier century's conception of the Christian God -- who is also metaphysical, difficult to picture, and imperfectly understood -- the concept of entropy owes some part of its ubiquity to fact that it is difficult to comprehend.

To speak of entropy as metaphor is to speak, in a peculiar way, redundantly. The word "entropy" was coined by Rudolf Clausius in 1865 from the Greek word for transformation, _tropos_; from that word also comes the name for a class of literary devices (tropes) to which metaphor belongs and which have, as their shared quality, a transformation in the apparent meaning of the words that contain them. But beneath this etymological similarity there is a difference: an entropic transformation is one in which something valuable ("free" energy, or order, or meaning) is lost, while a metaphoric transformation is one in which new meaning and new insight are created through juxtaposition of words. The one is a product of a creative process, the other a principle implicit in any process of physical degeneration. From a common root, two ideas that stand in contrast -- a relationship that is itself similar to the tension embodied in metaphor. "The dictionary," it seems, "is as disturbing as the world, full of teasing parallels and misleading coincidences."[6]

There is another sense in which entropy and metaphor are similar. As the prototypical probabilistic science, thermodynamics performed the historical task of challenging the easy assumption that inquiry could produce certainty. Metaphor, too, propels us from the terra firma of absolute signification toward a realm in which we must recognize our role in the construction or reconstruction of meaning -- a realm in which we run the risk of creating idiosyncratic or otherwise unintended meanings. Each in its own way, metaphor as literary device and thermodynamics as a science, locates human intelligence in the infirm territory of ambiguity.

It may be the special task of our age -- the age that can foresee even as it forestalls the waning of industrial culture -- to learn how to manage ambiguity; if so, it may be the case that metaphor itself is an appropriate model for our understanding. We are learning to give up the chimera of the absolute, in all the forms we have hoped to discover it; as we do so, we will of necessity turn to ways of knowing that do not dangle certainty in front of our inquiry as its longed-for object.

Literature has long been one realm in which such ways of knowing have been communicated. The insight that great literature affords is real, but is scarcely reducible to propositions related analytically by any sort of formal logic; the insight it affords is not certain and absolute. (This is because literature attempts to replicate experience -- an experience sharpened and deepened by authorial craft, to be sure, but experience that is nevertheless complex and therefore not only open to but in need of interpretation.) Politics, too, has for most of human history been understood as more art than science, and -- the brief rise and briefer, not-quite-complete decline of positivist political "science" notwithstanding -- political understanding bears a marked similarity to the understanding needed to comprehend or to benefit from great literature. There is an essential narrative quality to be found in both political experience and political philosophy, a narrative quality that binds together people, events, character, and circumstance into contexts that are at once particular and general. As with all narrative, causation is not inherent in the events themselves; the seeker of understanding must apprehend for him or herself the warp and woof of the phenomena under consideration, and formulate such interpretive propositions as seem supportable by that particular ordering of the material.

With some intermediate steps and corollary argument, we might steer this insight to this conclusion: the search for political knowledge is a species of literary criticism, a criticism that takes as its problematic text the events, features, and relationships of the political world. The parallel between literary criticism and political philosophy is reinforced by recognizing that there is an epic quality to be found both in great works of literature and in great works of political philosophy. Some works of literature can usefully be perceived as "encyclopedic" works -- works that capture, in impressive detail, the prevailing idea systems, technologies, scientific wisdom, range of human motivation and personalities, etc. of their time and culture. Moby Dick, for instance, stands as an encyclopedic representation of American culture at a particular point in time; Joyce's Ulysses serves the same function for a waning Irish culture; Cervantes and Shakespeare both represent, in their works, the apotheosis of their respective cultures. One critic[7] offers the Hegelian insight that cultures tend to produce such encyclopedic works only as the culture begins to wane -- which is yet another instance of similarity between literary and politically philosophical thought. The truly epic literary work -- the all-encompassing, encyclopedic work -- can only be a product of a culture past its peak, for it is impossible to compass a culture that is still open, growing, vital, and therefore indeterminate. Epic political philosophies are the products of periods of political crisis, and so are often produced as one form of political culture is transformed into another. For just this reason, only later generations can judge whether or not a work of literature or a work of political philosophy is "classic", and there are authors in both genres who have offered an ambitious, coherent, world-ordering vision -- a vision we may call, after Coleridge, an esemplastic vision -- only to have classic stature slip from their grasp as the movement of history turned (what they thought to be) their perennial concerns into temporally parochial fascinations. Works judged classics in both genres not only sum up an era in a definitive way, but manage to reach something of perennial relevance to the human condition in doing so.

So there is a continuity of function, a similarity in intent, and an occasionally hapless coincidence of fate between (what can be called) epic literature and epic political philosophy. It makes sense, then, to apply tools of analysis crafted for one genre to the other; our political understanding (the form of understanding whose history is recorded in the tradition of discourse that is political philosophy) will be the richer for it. One point of union between the two genres lies in the esemplastic power of basic, or root, metaphor.

Because the foregoing may make it sound as if this is primarily a work in the theory of literary criticism, I hasten to point out that my primary focus is the issue of order and its political ramifications; I discuss literature here only to begin pointing out the similarity between the two genres as avenues to a vision of an ordered world and to reinforce the importance of the role that metaphor can play in the construction of such a vision. This act of construction I take to be a political act, in the broadest sense of that term. And I do use the term "political" broadly; in what follows, I do not distinguish sharply between "social," "society," or "social order," on the one hand, and "political," "polity," or "political order" on the other -- a stance that some sociologists and political scientists would view with dismay. Ever since Locke, the tendency in the western political tradition has been to view the political order as a set of relations that are distinctly different from (and posterior to) social relations. The point has some importance in the Lockian tradition, for Locke's careful defense of a populace's "right to revolution" depends upon this distinction in fundamental ways; to deny it seems to place one firmly in the Hobbesian camp, along with others who find in political relations the sole source of social order, and who therefore view political revolutions as the largest evil that can befall a community. But there are ways of denying Locke's distinction without immediately retreating into the world of the Leviathan. Our escape from that world depends upon the definition we attach to "the political," upon the range of phenomena we are willing to comprehend with that term.

One definition that allows us such an escape is the one that is implicit in much contemporary radical social criticism: "'the political' comprises every conceivable form of power, wherever it is found."[8] This is an acceptable definition, so long as we are not thinking, as a mechanist would, that "power" means "effective power" -- i.e., some increment of power left over after the vectors of competing powers have been subtracted or otherwise taken into account. Such an interpretation would mean that the struggle for equality of empowerment (one way of defining one goal of some movements for social justice) is a struggle for the transcendence of politics -- a goal so ambitious as to be somewhat less likely of realization than the goal of social justice, however utopian this latter goal may be. The non-mechanist recognizes that individual empowerment, even when effectively cancelled by countervailing power, is always and everywhere political.

Just as the most fundamental political question concerns the definition of "political", so the most fundamental political power is exercised in conceptualizing and ordering our political experience. There have been societies (perhaps here one can not rightfully call them polities) in which this power was not recognized as a political power: there have been societies in which the mechanisms through which governance was effected were not the result of conscious debate, design, or action but were instead the product of inattention, or of reliance upon faith, myth, or tradition. That is, there have been societies in which the issue of political order was not experienced as an issue at all, let alone as a political issue, because answer was given to basic political questions about the structure and function of political regimes, the ends those regimes served, and the principles that set limit to their realms of authority only implicitly and non-noetically. A definition of "political" that encompasses this insight might (when the gender specificity found in the original is purged from it) read something like this:

> 'Political society'...is that dimension of total reality which concerns our continuing attempt to order our lives with others in light of our imperfect but noetically differentiated understanding of the structure of existence. Therefore political activity, in this larger sense, must be seen as the process of participation by humanity in the drama of humanity....Politics is the participation by humans with their fellows in a greater order of things, and the history of philosophy is the continuing story of our imperfect yet impressive attempts to articulate and symbolize this experience.[9]

"To order our lives with others...;" "the participation by humanity in the drama of humanity...;" "participation by humans with their fellows in a greater order of things...;" these phrases suggest that the essence of politics is order. During "normal" or non-revolutionary times, this essence may be difficult to discern beneath the clutter of everyday political activity; but even so, that activity depends upon a shared and general sense of the legitimacy and appropriateness of the vision of order embodied in the "mechanisms," devices, institutions, organizations, and processes in and through which humans reconcile their individual wants, needs, ambitions and visions with the inescapable fact of public and social life. Despite the fact that the individual may encounter those "mechanisms," devices, institutions, organizations, and processes as "givens" in a particular political world, and so may give no thought to their origin and development and see no prospect for their further change, they are neither immutable nor the product of a creation *ex nihilo*. If they are the product of a noetic consciousness, they will have had, by definition, some sort of supporting rationale, which served to grant them legitimacy in the eyes of those who fall within their purview.

And here we can see, through history, a peculiar quality of humans: rather timid of asserting anything solely on their own say-so, or perhaps made anxious by the implications of pure ontological fiat, humans seem by nature drawn to justifying their political arrangements with appeals to some supra- or at least extra-cultural vision of order. When these visions of order are discerned in the cosmos at large and then carried back into politics, we can justly ascribe political importance both to the cosmological vision and to the vehicle by which its transport is effected. Metaphor -- whose root meaning is "carrying into" -- is often that vehicle; entropy is one such cosmological idea.

This suggests that any order created, imagined, managed, or otherwise brought to realization by humans is political in nature (or at least, that it has the potential to be so, for not all visions of order need be communicated outside of the mind that conceives them). Throughout history, what is commonly understood to be "political order" -- the creation and maintenance of political institutions, the keeping of the King's peace, the reconciliation of individual will with community will -- has most often been the product of the exercise of power of some sort, and that power has often been the power of force -- the sheer mechanical ability to cause pain and discomfort. It is therefore understandable but short-sighted to confuse "the political" with "every conceivable form of force." There are other instrumentalities available for the realization of order; there are other forms of power than those that flow from the barrel of a gun.

One form of non-violent "force" -- I put the word in quotation marks because it strikes me as a metaphoric use -- is rhetorical force: the power of suasion of logical argument. Robert Nozick has written recently of this kind of force, wondering whether it too might be subject to the same sort of moral condemnation that our culture attaches to the use of coercive violence. ("Why are philosophers intent on forcing others to believe things? Is that a nice way to behave toward someone?"[10]) Nozick instead offers "Philosophical Explanations," thinking to avoid whatever moral problems may be involved in <u>forcing</u> belief by explicitly repudiating forceful argument in favor of the gentler art of spinning out a coherent vision. But note that in turning from the "coercive" force of logical argument to the more seductive appeal of explanation, Nozick does not fully avoid the problem: humans have a need to make sense of things, and to proffer coherent explanation in lieu of convincing argument is to substitute the carrot for the stick, the bribe of candy for corporal punishment. (We may even suspect that Nozick knows this, and is actually selecting the more effective vehicle for changing beliefs; why else would he point out that a forceful argument is much more likely to create resistance than to win converts?) I raise this issue not because I want to solve Nozick's problem for him, or even to argue him into a corner from which his only escape would be to give up philosophy. Rather, I mention Nozick because his work emphasizes the continuity of function between argument and story, analysis and narrative, and (more broadly), philosophy and literature. We must, it seems, amend Whitehead's famous advice: if you would understand an age and a culture, look not to the issues that are the subject of learned disputation, and not only to the unvoiced assumptions of the age, but also to the stories people tell themselves, the archetypical patterns represented in their literature, which offer them the means to make sense of their world.[11] Just as the most secure assumption is the unvoiced and therefore unchallenged assumption, and the most secure premise is the suppressed premise, the explanation likely to gain the broadest assent for the longest period of time is the explanation grounded in a shared but non-noetically apprehended archetype, the popular but not-consciously-metaphorical metaphor.

These devices offer their wielders the power to construct in the minds of others their vision of order -- a power made all the more effective for not being felt. This is why "there can be no 'innocent' art," and why a critical political philosophy needs to take account not only of the arguments it encounters, but also of the narrative and literary elements, such as the pattern of metaphor, in the epic works it considers. Certainly any criticism of Hobbes' Leviathan (to take perhaps the easiest example) that does not begin by noticing that Hobbes, while demeaning metaphor, has unselfconsciously taken metaphor literally is bound to pass wide of the mark -- if it doesn't mistake Hobbes' whole enterprise for satire. To join with Hobbes in his non-self-conscious acceptance of the mechanical metaphor at the root of his work -- not to see, that is, that there *is* a metaphor at the root of his work -- is to accept without contention that which ought to be contentious; it is to accept his work at its most basic level, the level at which he seeks to re-order our sense of what it is to be human and political.

This should begin to explain why the subject of root metaphor offers interest to students of politics. Why, then, entropy?

The simplest answer is that the idea of entropy, particularly its use as metaphor, intrigues me. Were this study to reflect, in its form, one of the primary characteristics of literary and cultural modernism, its author would need to offer no further justification: my personal interest in the subject would be justification enough, and the degree to which this enterprise succeeds or fails would depend solely on the strength of the personal vision, the idiosyncratic integument, that lies behind it. This is, peculiarly, a development to which the idea of entropy itself bears a relation. It is not yet quite a commonplace to observe that the literature of earlier centuries relied upon the "mechanics" of plot in ways that contemporary literature does not. Whereas nineteenth century literature derived its "energy" -- its compelling attractiveness to audiences -- from the essentially mechanical devices of plot, which served to create suspense and thus to draw the reader in, contemporary literature tends to derive its compelling attractiveness from the esemplastic power of the individual voice behind it.[12] If Dickens is still read today for contemporary enjoyment, rather than historical interest, it is because we are willing to forgive him his overly mechanical plots in order to appreciate the ordering vision behind his classic voice. Dickens dates from the mid-nineteenth century, which was still in the thrall of Newtonian mechanism; from that image of a clock-work universe we have moved, in little more than a century, to an image of atoms and the void, particles moving randomly through space, an image of fundamental chaos (with, to be sure, statistically improbable islands of order and regularity within it) illuminated only partially by the idea of entropy and the probabilistic metaphysics it gave sustenance to. In the mechanical universe we have order, regularity, certainty -- and a mechanistic literary convention not experienced as convention; in the thermodynamic universe we have partial understanding, limited in its object to the tiny islands of order and regularity that human will can discern or preserve in a sea of chaos, and a literary convention of the unconventional, the idiosyncratic. In recognizing convention as convention, and in casting it aside in favor of reliance upon literary voice that speaks with authority only as an individual voice, modern literature records in its stylistic conventions this transition in ontology.

But if we agree with Henry Adams that in our efforts to make sense of the world, we yearn for the comfort of concepts in which "an energy not individual is hidden,"[13] we will not be satisfied with a simple assertion of authorial interest as justification for our inquiry; we will want reasons -- or at least, an interesting story.

A compelling argument begins from premisses that win our assent; a compelling narrative, with a scene that piques our interest. The prologue, besides being an attempt to replicate for you my own introduction to the idea of entropy in all its manifest, confusing, diversity of application, will (if it has had its intended effect) have stimulated your curiosity about the widespread use of the idea of entropy. Like few other ideas from the sciences -- Newtonian mechanics (which entropy directly challenges) and Heisenberg's principle of indeterminancy being its only peers in this regard -- entropy has been lifted bodily, as it were, out of its discipline of inception and turned to account as a lens through which to view all manner of phenomena. Now, this alone might be sufficient to draw our interest in entropy as root metaphor. Despite the fact that shortly after its complete statement thinkers started using the idea of entropy as a fundamental, explanatory idea, as yet no critical history of this usage exists. The current work thus fills a gap in the history of the human intellect.

But there are, in addition, other reasons why entropy is a particularly timely subject for investigation. If the twentieth century is to be remembered as the age of ambiguity, that is due in no small measure to the idea of entropy itself; thermodynamics, as it developed, challenged the mechanistic world vision that earlier centuries had taken as an article of faith, and also served to undermine the easy confidence in positivism that had been predicated upon mechanical epistemological theory. As the chapter on the history of entropy makes clear, entropy played a crucial role in the development of modern, non-mechanistic physical theory.

And there is, finally, this compelling reason to explore entropy's use as root or unifying metaphor: the problems of industrial culture are in large part traceable to our unwillingness to reconstruct our institutions in light of the truths of thermodynamics. Which is to say, the use of entropy as metaphoric lens (or lenticular metaphor?) could lead to the articulation of an epic, encyclopedic work of political philosophy grounded in the language and imagery of thermodynamics. Were such an epic political philosophy to be produced now, it would, of course, be a sign that our industrial culture had achieved its fullest flower and was in state of crisis, or decline.

Several points about the work that follows need to be made clear. First, the work itself is in the nature of the biography of an idea. Like a biography of a human subject, it is not easily reducible to a single, clearly stated thesis; and yet, like those biographies, at its end there will be relatively obvious grounds upon which to draw conclusions concerning the flaws and strengths of it major character. Those conclusions can be foreshadowed here, where they may serve as thesis statements: the idea of entropy has enjoyed widespread use as a root metaphor during two distinct eras in American history. Those uses demonstrate that the idea of entropy, when used as a root metaphor, has sufficient breadth of scope and adequacy in precision (the two formal criteria for root metaphors discussed in the next chapter) to be counted as a root metaphor. And yet, the entropy metaphor lacks something, something that has kept it from serving as the foundation idea of an epic political philosophy. That lack has as much to do with an evolution in our culture's attitude toward such use of metaphor as it does with any shortcoming directly attributable to the idea of entropy when used as root metaphor.

Second, though the title of this work is "Entropy as Root Metaphor" it occasionally takes within its purview the metaphoric uses of thermodynamics in general -- as if, it would seem, the law of entropy were the sum total of the perspective of thermodynamics. The problem this presents is most clear in the work of Brooks Adams, who attributes such qualities as "force" and "energy" to ideas, social movements, civilizations, and races, but nowhere makes explicit reference to the idea of entropy. (In this, Brooks constitutes an exception among the thinkers whose work is discussed at any length in this paper. Each of the others -- Henry Adams, the economists discussed in chapter six, and Thomas Pynchon -- makes explicit reference to the idea of entropy.) Is it fair, then, to include Brooks as a subject in this work? I believe it is, for two reasons. First, partisans of particular root metaphors need not make explicit use of the particular term that gives the root metaphor its name. Each root metaphor suggests a pattern, a style of thought, as well as a characteristic vocabulary of key terms, and it is sufficient for that pattern to be present; the thinker need not use each and every one of the key terms in order to be described as a partisan of the root metaphor. In Brooks' case, it is sufficient that he is using such terms as "energy" and "force" in ways that go beyond the usage given to them in physics. Second, Brooks takes as his avowed aim the examination of the dissipation of cultural energies through history -- and wherever there is dissipation of energy (as we shall see in chapter three), there is entropy. If the energy being dissipated is metaphoric energy, it is fair to say that entropy, too, is present metaphorically.

Next, it needs to be pointed out that because a root metaphor is a <u>pattern</u> of metaphor that is larger than any specific example of itself -- a definition that is elaborated in chapter two -- any evaluation of a root metaphor must wait upon the clear presentation of that pattern. Also, the term "root metaphor" denotes an ideal type; as Pepper notes, one rarely finds them in their full, complete, unadulterated form in the work of any single author.[14] For this reason as well, our assessment of the virtues and flaws of entropy as root metaphor must wait until the last chapter. To judge the metaphor solely on the basis of its presentation in the works of one or two thinkers would be hasty.

Finally, I would like to make clear from the outset that in examining the case that can be made for seeing entropy as root metaphor I am not reviewing an argument that anyone has made. To my knowlege, no one has claimed that entropy is, or is becoming, or ought to become a root metaphor. This is to be expected; a root metaphor used consciously and literally, I have suggested, is no root metaphor, but instead ground for satire. This means that any attempt to review and to criticise such systematic use of a metaphor is open to a charge of being a form of "straw man" argument; the thing to be criticised -- the root metaphor -- can be criticised only after the critic has brought it to the surface, only after the critic has, in large part, created it. And yet the examination of entropy as root metaphor is not an idle exercise. There have been two distinct periods in history when the idea of entropy enjoyed its greatest currency outside the technical realm of thermodynamics, periods when the idea of entropy was taken up by poets, literateurs, students of history and society, philosophers of art and life and existence. We stand to learn something of the intellectual foundations of our era by examining these uses.

The first of these periods coincided roughly with the close of the nineteenth century; the second, with the period of cultural, social, and political turmoil commonly known as the sixties, and which dated (roughly) from the mid 1960's to the early part of the 70's. It may be the case that the popularity of the entropy metaphor has very little to do with any similarity between the two eras, for the possibility exists that the currency of the idea was the product, in both times, of individual genius rather than historical or cultural forces. And, in fact, each era saw an American thinker of major stature use the idea of entropy as the cornerstone idea of an ambitious, world-ordering vision: Henry Adams, historian, during the 1890s, and Thomas Pynchon, novelist, during the 1960s. Certainly their genius and their works played some role in the dispersion of the idea in their respective times. And yet, the historian is charged with discovering pattern and can not rest easy with an explanation that allows social phenomena to be the product of the essentially arbitrary careering and careening of individuals through time unless other possibilities have been explored and discarded. Further, the contributions of individuals can be kept in perspective by noting that individual genius does not operate in a vaccuum. Geniuses speak to their times, and the reception that their ideas are accorded -- the reception that distinguishes genius from idiosyncratic crank -- has as much to do with a vague "temper of the times" as it does the inherent quality of the message. Finally, individual genius can not account for widespread, fundamentally different, nearly simultaneous manifestations of an idea. Henry Adams, for instance, may have given the idea of entropy its most complex use as the foundation idea in his philosophy of history, but that does not account for the fact that thermodynamic imagery crops up, *before* Adams published, in such diverse places as Freudian psychological theory and the ontological perspectives of William James, Henri Bergson, and Wilhelm Ostwald. Nor does Pynchon's popularity in the sixties account for other contemporaneous uses in the works of biologists, information theorists, and economists.

This suggests that there is a similarity or a continuity to be discerned between the close of the nineteenth century and the waning of the decade of the sixties. Parallels between the two periods are not difficult to discover; both saw immense change take place in the structure and perceived function of the American polity. The first of these eras marked America's coming of age as a world and an industrial power, with all the attendant social dislocations that that suggests, and the second saw a subtler shift toward the creation of a *de facto* world industrial order made in the image of the American technological-industrial empire. In the 1890s, the idea of entropy appealed to those, such as Adams, who felt an era coming to a close with the turn of the century, and -- somewhat paradoxically -- to those who were more sanguine about the immense powers and energies that industrialization had placed at the disposal of our race. A similar paradox infected the use of the idea of entropy in the 1960s. Though any *fin de siecle* feeling afoot then would have been a few decades premature, there was, then, a widespread and pointed sense that the American Dream was bearing bitter fruit, and that catharctic change was in the offing. Entropy, paradoxically, could serve to explain why things had soured, and also as the foundation of a new, redemptive vision.

At least three writers from the seventies have suggested that entropy is the cornerstone idea of "a new world view," one in which, among other things, our ecological problems will become more calcitrant. That neither Jeremy Rifkin, Hazel Henderson, nor Harold J. Morowitz speak in terms of root metaphors when discussing entropy could be a mark of their naivete, or a result of the shallowness with which they treat the idea (a shallowness, it should be noted, that most likely results from their roles as popularizers) -- or negative evidence supporting the claim that they make of entropy a root metaphor. Henderson seems to be employing a metaphor consciously when she speaks of "the entropy state" ("a society at the stage when complexity and interdependence have reached the point where the transaction costs that are generated equal or exceed the society's productive capabilities") but this is not a theme she develops with any consistency.[15] Notwithstanding that Carl Sagan found Morowitz's essays "a delight to read" (as the jacket copy tells us), they are generally brief, superficial treatments of interesting subjects, the charm of which lies, as with good metaphor, in provocative juxtaposition (e.g., "Christ, Clausius, and Corrosion"), but which delve no further than a popular audience would care to go. One reads his four page history and typology of the concept of energy, for instance, without finding any suggestion that some of the uses of the term are metaphorical.[16] And, while Morowitz does suggest that we are entering into an "Age of Entropy" and that the "Entropy Crisis" lies behind our energy and environmental crises, here too the theme finds no further elaboration.

Jeremy Rifkin comes closest to making the case for seeing entropy as a root metaphor appropriate to a new vision that will allow us to make sense of the problems of industrial society and culture. In Entropy: A New World View he argues that "the Entropy Law will preside as the ruling paradigm over the next period of history," and indicates that only within that new paradigm will we be able to resolve the "malaise" of industrial society and the "universal crisis at hand."[17] The book is beset by numerous problems, but what matters most for our purposes here is that Rifkin relates every subject he takes up -- from medicine to cities choked with traffic to the spiritual paucity of modern lives -- to the idea of entropy while adamantly denying that there is metaphor, or anything like it, in the way he stretches the concept to cover his catalogue of "new-age" solutions. This literal mindedness leads Rifkin to miss much of the irony the subject affords: in denying meaning to metaphor he seems to be joining those "Newtonian" philosophers, Hobbes and Locke, whose mechanism is at once the orthodoxy that Rifkin hopes to challenge with the idea of entropy and the source of their distaste for metaphor.[18]

Other writers of greater intellectual weight have taken up the entropy law and applied it within their disciplines, only to have their range of interest expanded by their contact with it, as if the idea of entropy were a worldly palimpsest, propelling those who encounter it into new meanings and vistas. Thus, Nicholas Georgescu-Roegen, an economist, writes at length of time and ontology; Norbert Wiener, the information theorist (and coiner of the term "cybernetics"), writes of the end of history; Frederick Soddy, a Nobel Laureate in biology, endured the ignominity consequent upon having his writings in economics dismissed as the work of a crank; and Ilya Prigogine, another Nobel Laureate in biology, has recently written of traffic flows and patterns in cities.[19] None of these writers, though, has displayed what Sheldon Wolin calls "the architectonic impulse," the urge to create grand theories ordering the many facets of our experience.[20] While the idea of entropy was, in the 60s and 70s, clearly "in the air", no one then quite managed to distill the various strands of thought that entropy suggests in a variety of disciplines into a coherent whole.

Which is to say, no one quite managed to create an epic political philosophy grounded in the ideas of thermodynamics used as metaphor. If it is true, as Hegel says, that the Owl of Minerva takes wing only with the setting of the sun, we may find in this a sign that our industrial culture is not yet truly on the wane. And yet, there is another explanation, one that might offer more promise to those who believe (as must anyone who has some familiarity with the concepts of thermodynamics) that there is much systematic insanity passing under the guise of rationality in our industrial culture: perhaps the absence of an epic political philosophy grouned in thermodynamic imagery has to do with a different historical development. In the past, the boundary that distinguishes noetic from non-noetic thought has moved with time, as we have brought more and more phenomena under the scrutiny of reflective self-consciousness. Perhaps that boundary has now moved past metaphor.

These are the themes that will engage our attention as we inquire into the various uses of the idea of entropy as an organizing metaphor. The work before you falls into three distinct sections. Chapters two and three comprise one section, in which we cover the groundwork necessary for an examination of the uses of the idea of entropy as metaphor. (Chapter two discusses root metaphor, defining it, giving instances of it, as well as offering criteria by which we can judge whether particular root metaphors are root metaphors and, if so, whether they are good or bad root metaphors. Chapter three, by recounting the history of the idea of entropy, provides the reader with a sense of the "system of associated commonplaces" that attaches to the idea, which will aid in the understanding of the idea's metaphoric signification.) The next section examines the ways in which the idea of entropy was being used in the late nineteenth century. (One chapter focuses on the work of Brooks Adams, placing his use of the entropy metaphor into an historical context, while the next takes an extended look at the way in which Brooks' brother Henry used the idea of entropy in communicating his "scientific" philosophy of history.) The third section examines more recent uses of the idea of entropy as root metaphor (and discovers that the relationship between Brooks and Henry Adams has a modern parallel: one chapter in this section examines the way in which the laws of thermodynamics are illuminating economics, which has a ready parallel in the literalist use that thermodynmics found in Brooks' work, and the other chapter traces the importance of entropy and thermodynmic concepts in the work of Thomas Pynchon, who makes obvious in his work his intellectual debt to Henry Adams). Finally, a concluding chapter offers speculations on why entropy has proved to be such a popular idea, judgments on the virtues and flaws of the entropy metaphor as a device through which to interpret the world, and some thoughts on the contemporary status of root metaphors themselves.

Having previewed the structure of the work as a whole, we now turn to an examination of root metaphor.

Chapter Two

ROOT METAPHOR

"Metaphor is the dream work of language...."
Donald Davidson[1]

Our examination of root metaphor begins with an examination of the nature of metpahor itself, a subject that has had much attention recently. Philosophers are turning to the study of metaphor with new interest and discovering there fundamental insight into the nature of language and the creation of meaning. Max Black, Richard Rorty, W. V. Quine, Wayne C. Booth and others have taken up metaphor as an object of study, and some among them have made analysis of the use of metaphor by other philosophers a basic part of their critical programme. The realization that for philosophers the question cannot be whether to be metaphorical at all, but concerns instead the manner and means of being metaphorical, marks the decline of the analytic school of philosophy and the hold it has had over the Western mind. Far from being verbal slips, mere ornament, a product of falsity in the signification of words, or purposeful inaccuracies of limited heuristic value and dubious metaphysical stature, metaphors are coming to be seen as a necessary and telling element of any philosophical discourse. We reveal ourselves in our metaphors--reveal our habits of mind, our culturally or individually idiosyncratic patterns of connection-making, our aesthetic field upon which so much else depends and is constructed.

The *Princeton Encyclopedia of Poetry and Poetics* defines metaphor as "A condensed verbal relation in which an idea, image or symbol may, by the presence of one or more other ideas, images or symbols, be enhanced in vividness, complexity, or breadth of implication."[2] This definition is broad enough to include all manner of tropes, not just those normally designated by the term "metaphor," and this is appropriate. One may sympathize with those grammarians and arbiters of prose style who bemoan the loss of precision in language, and still accept this broader, less precise usage, for there is some warrant for it in the nature of the thing. At first glance, analogy, simile, metaphor, and symbol are not discrete entities, sharply distinguishable one from the other, but instead lie on a continuum defined by the degree of overt comparison they contain. In analogy, the comparison is open and avowed, and is usually explicitly elaborated to make a specific point: "He ran like a rabbit, didn't he?" In simile, the comparison is open and avowed, but its limits are set by the reader or hearer rather than its author: "He is like a rabbit." Metaphor presents its comparison in a bare statement that is often a literal absurdity ("He is a rabbit"; or, more poetically, as when Shelley called the west wind "the breath of Autumn's being," Autumn not being corporeal at all), and it is up to the hearer or reader to puzzle out, with a fine attention to nuance, detail, and context, exactly which among the "system of associated commonplaces" belonging to the vehicle (the rabbit, or the "breath of Autumn's being") are being predicated, and with what weight, of the tenor (the man, or the west wind). In symbol, the element of comparison is submerged: "Instead of saying that A is like B or that A is B, the poet simply talks about B, without making any overt reference to A at all. You know, however, that [the poet] intends A all the time, or, better, that [the poet] intends <u>an</u> A...," for it may not be clear exactly what is being compared to what.[3] Owen Barfield, who speaks here of A's and B's, goes on to note that there is a quality that increases as the degree of overt comparison decreases: "If I were writing this article in Greek or German," he writes, "I could run the six words 'say-one-thing-and-mean-another' together and use the resulting conglomerate as a noun" to stand for the quality he wishes to describe. He lights instead on "tarning," a corruption of the German word <u>Tarnung</u>, which refers to the practice of hiding a meaning in words, as from a censor.[4] Metaphor, in occupying the middle ground of this continuum, achieves its power through a mixture of overt comparison and literal dissimulation, or tarning. These are qualities that the other tropes share to greater or lesser degree, so a definition of metaphor that allows the concept to be a bit "fuzzy" around the edges seems preferable to one that defines it more rigidly.[5]

Metaphors encourage us to see the similarities in dissimilars; they encourage us to focus our attention selectively, bringing to the fore certain aspects of the entities brought into metaphoric relation and relegating other qualities to the dark fringes of background. This is not meant to suggest that metaphors merely reveal a pre-existing similarity between the objects, ideas, or what-have-yous that serve as vehicle and tenor. But neither can we say that language has the power to alter objects in the world, creating in them the similarity that metaphor articulates. The way out of this paradox lies in the suggestion that the essence of metaphor is relation, and that a new, fresh metaphor creates a new, theretofore non-existent relation. As C. Day Lewis puts it, "We find metaphoric truth struck out by the collision rather than the collusion of images."[6]

Since humans construct cognitive experience out of materials at hand, the types of metaphor they create and employ are important indications of the relative emphasis they give to different components of the world of experience available to them. Some individuals draw upon nature as a source of metaphor, but ~~brings~~ bring to their experience of nature no more insight or curiosity than is required to reaffirm the metaphoric significations that have been cliches from the time of Aesop: thus, for these people, foxes are wily, lambs innocent, a thoughtful person ruminative and a stupid one bovine. Others draw on nature as a source for metaphor without having their perception filtered through layers of acculturation, and so may make fresh, original connections--much as children often do. Still others may turn away from nature entirely as a source for metaphoric inspiration, and so place themselves squarely within one of the more disturbing trends of modern culture: the tendency to draw meaning solely from the built world, and the inability to look beyond and beneath the human environment.[7]

An individual's use of metaphor is shaped by the patterns of metaphor that prevail in that individual's culture. This is true of brilliantly original metaphors as well as cliches, for it is beyond the power of a single person to affect, through a single instance of metaphor, the system of associated commonplaces that the vehicle of a trope evokes; the images, qualities, and thoughts that an instance of "tarning" brings forth are part of the cultural background, the "givens," of figurative speech.[8] "The meaning of a metaphorical sentence is never contained entirely in the sentence but requires a context of material knowledge or assumptions on the part of the speaker or the listener.... The success of the communication depends on the sharing of that context, whether physical, social, psychological, or historical."[9] To give but two brief examples: the words "west wind" evoke one group of images within a culture whose prevailing winds, and hence weather patterns, move west-to-east, and quite a different set of images for people whose climate or micro-climate normally receives its weather from a different direction. To the latter group, the words "west wind" might conjure up the same images and emotions that the words "nor'easter" do for a resident of coastal Maine. Or, to call a man a coyote in front of an audience of shepherds will communicate one sort of idea of the man, and to do so among a group of hunters and gatherers--who may view the coyote as a totemic animal, a kindred spirit with whom they have an empathetic bond--will communicate a radically different image.[10] Metaphor is a social act, because metaphors rely on a shared context of values, knowledge and assumptions (i.e., because communities create metaphor), and because through metaphor shared values and assumptions are articulated, reinforcing group identity (i.e., because metaphors create communities).

These general remarks on the nature of metaphor serve to introduce a discussion of a particular sort of metaphor, the root or basic metaphor. These metaphors are qualitatively different from the metaphors we customarily recognize as literary devices (though these latter can be _instances_ of root metaphor). The most obvious difference is that root metaphors are not single metaphors but patterns of metaphor. The pattern is manifest as a conjunction of a particular vehicle or identifiable class of vehicles with a large quantity and a great diversity of tenors. This characteristic, and the other identifying characteristics of root metaphor, will become clearer as we turn to an analysis of how root metaphors originate in the mind and of the role such metaphors perform in human thought.

The first of these topics is admittedly obscure, and what can be achieved here is more probably coherent explanation than certain and falsifiable knowledge. We begin, then, with the idea that all metaphor has its origin in what we can call, after Fenichel,[11] the primary processes of mind. These processes are marked by a lack of verb tense, lack of linguistic mood, lack of negatives; they are sub- or non-lingual, having a coherence, system, pattern, or (broadly) "logos" that is different from that of speech or language. Unlike the secondary processes of mind, which for the most part operate within language and which concern themselves with objects, things, persons, and their qualities and conditions, primary processes of mind are concerned solely with relationships. The material in the primary processes is not readily accessible to the secondary, conscious mind; since the former is sub-lingual, "formidable problems of translation" are present in any attempt to bring the products of primary consciousness into secondary consciousness.[12]

Bateson tells us that to say that the objects of primary processes of mind are relationships is but another way of saying that those processes are metaphoric.[13] But metaphor is a linguistic device, finding expression in words -- it is an instance of metaphor to say that visual art contains "metaphors" -- and these processes are non-lingual; to call what goes on in primary processes of mind "metaphor" is inappropriate. A more suitable name might be "proto-metaphor", in recognition of the way in which metaphors are formed. Anyone who has created a metaphor has had the experience of having a gleam of insight concerning a correspondence or relationship, for which one can find words only with some thought and reflection; for a moment, one is suspended within the primary processes of mind, until, through a "formidable act of translation", the insight or kenning beyond speech is formulated into words that just may be capable of communicating it to another. That the product -- metaphor -- strains the limits of language, presenting itself as a *prima facie* absurdity, is a sign of the distance between the _logos_ of primary processes and the _logos_ of speech. "In the primary process, (as in art)," Bateson tells us, "there are no markers to indicate to the conscious mind that the message material is metaphoric,"[14] but (he implies) in the act of translation metaphors pick up such a marker. Bateson does not tell us the conditions under which a metaphor will fail to be identified as such, and indeed does not discuss this possibility at all. There are at least two such conditions (in addition to pathological disorder of the mind, which will not concern us here).

First, a metaphor may be marked by the mind as containing a lesser order of "tarning" than it actually has; the mind may perceive it as an analogy, in which the relevant features of the vehicle can be "mapped" directly onto the tenor. We are now, incidentally, prepared to distinguish more fully between metaphor and analogy. Most often, analogy has its origin in secondary processes of mind; one feels the need for an analogy and goes looking for it. This is just the reverse of metaphor, which originates in an inarticulate sense of relation and is only put into words with difficulty; with metaphor, the need one feels is for words, not an illustrative example. (In this, analogy is similar to allegory, which also originates in rational, secondary consciousness.)

The second condition in which metaphor is not identified as such by the "translator" (that is, the bridge between primary and secondary processes of mind) is of greater importance to an understanding of root metaphor. Even in non-pathological minds, metaphors may be marked as literal truths when they are translated from proto-metaphors into words. This, in turn, seems to have several sources. One is difficult to see as anything other than error resulting from lack of experience or imagination: in the flash of excitement that comes with having found just the right words for an insight that theretofore resisted clear statement, an individual may mistake "just the right words" for "the only words." Stephen Pepper tells us that anyone who has not had the opportunity to compare how the world looks when seen through one root metaphor with how it looks when seen through another "will inevitably accept [the former vision] as self-evident or indubitable",[15] and this is what is meant here. A second source of this marking of metaphor as literal truth has to do with habit. No less than with other operations of our minds, the process by which proto-metaphors are translated into secondary consciousness is subject to the mind's tendency toward economy of effort, and habit is the primary means by which such economy is obtained. The dead metaphors in which any language abounds are one artifact of this tendency; certainly the majority of speakers who use the word "feedback," for instance, to stand for "constructive non-threatening criticism", are signifying their uncritical acceptance of an habitual form of connection-making. They are not consciously intending to model human relations after cybernetic systems -- indeed, they are not consciously intending to establish any relation at all, except the one implied by their effort to communicate a concept as succinctly, as economically, as they can.

The part of the mind that translates the products of primary consciousness into objects of secondary consciousness is, in addition to being subject to the effect of habit, a thoroughgoing opportunist: it will take whatever path toward a "solution" of its problem that produces acceptable results. One such path lies in analogy. If we could, for a moment, further personify what is after all a capacity, and eavesdrop on its musings as it struggles with its task, we might hear it reason along these lines: "This relationship, for which I have no words or conceptual vocabulary, is similar to that relationship, for which this particular language has seemed to work; therefore, I will press this particular language into further service to represent this new relationship." This is similar to what Pepper tells us concerning the invention of root metaphor: "The method in principle seems to be this. A man desiring to understand the world looks about for a clue to its comprehension. He pitches upon some area of common-sense fact and tries...to understand other areas in terms of this one. This original area becomes then his basic analogy or root metaphor."[16] Note that the language that applies to the original area of understanding need not be metaphoric. If the area of "common sense" understanding is a machine, then mechanistic language is certainly not metaphoric when applied to it. Note also that Pepper's language offers "basic analogy" as a synonym for "root metaphor" when the two ought properly to be distinguished. A basic analogy is the result of comprehension firmly located in secondary processes of mind being communicated through an illustrative model; the fact that it is "basic" merely means that the analogy is popular and used often. All metaphor, including root metaphor, results in comprehension and language arriving in the conscious, secondary process mind together.

We are now ready to offer a definition of root metaphor, one grounded in the process by which it comes into being, and which distinguishes it from other, lesser metaphors. A root metaphor is a pattern of relational imagery in rhetoric and thought, widely shared among individuals, that results from the development of a consistent pattern of selectivity in the act of translating proto-metaphors into effable insights about our world and the objects of our attention. Particular metaphors may be instances of root metaphors or not, but an instance of root metaphor is not the root metaphor itself, for a root metaphor is a pattern of metaphor. As we have seen, the pattern of selectivity in translation that produces root metaphor has several causes, including failure to recognize or to imagine alternatives, and an habitual reliance upon, or conscious choice of, a particular conceptual vocabulary in which to present an idea.[17] An ordinary metaphor is an instance of root metaphor when it forms a part of, contributes to, helps to create, or extends some larger pattern of relational imagery within the rhetoric and thought of the culture in which its author is attempting to communicate.

It may be helpful to conceive of the relationship between primary processes of mind, the translating function of the secondary processes of mind, and the pattern of relational imagery that is root metaphor in terms of illustrative images and analogies. The primary processes of mind might be seen as a roiling, bubbling stew of extra-lingual associations. The translating function of the mind operates as a sieve, allowing only certain types of associations to be brought to the conscious mind, or perhaps forcing all such associations into a form that the secondary processes of mind finds acceptable, if not familiar. Root metaphor, the resulting pattern in language and thought, is thus a kind of linguistic shadow cast by that sieve. This image suggests that root metaphors are not fully introjected into primary processes of mind, although this is a subject we have not taken up -- and with good reason. It is impossible to know whether root metaphors are introjected only as far as the sieve, or deeper, into the primary processes themselves, for the lamp of language makes it impossible to see exactly what goes on in the darkness of the primary processes.

The possibility that patterns of selectivity in the act of translation -- the patterns that produce the larger patterns of relational imagery in rhetoric and thought that we call root metaphor -- are the result of conscious choice leads us to our second manner of characterizing the differences between ordinary metaphor and root metaphor. This second way focuses on the function or role that root metaphors perform in our thought, rather than on their origin in our thought. Root metaphors are metaphors that "work," if by work we understand: 1) organize and extend human perceptions across the broadest ranges of subject matter and context, while carrying with them detailed implications for our understanding of human nature, social organization, and cosmic/natural processes, systems, or entities; 2) comprise characteristic patterns of perception that are "laid over" the processes of the mind itself, so that the metaphors imply characteristic epistemological positions such that the literal absurdities in which the metaphor finds expression become, instead, near tautologies; and 3) are sufficiently congruent with the experience of enough people that the perspective the root metaphor entails is non-idiosyncratic, i.e. is experienced neither as (greater or lesser) poetry nor as (greater or lesser) paranoid delusion.[18]

It should be clear from this that not all metaphors have the potential to become root metaphors; some metaphors simply cannot support the breadth of application that others can. Pepper identifies four root metaphors (stating bluntly that they "are all the root metaphors I have discovered"[19]): formism, organicism, mechanism, and contextualism. A brief description of each is appropriate.

Pepper finds formism in the works of Plato, Aristotle, the scholastics, and their modern day heirs. It takes as its root image the image of similarity, focusing on the continuities of quality that allow us to group objects meaningfully in spite of their particularity. In doing so, it ascribes ontological status to form itself. Mechanism, which counts among its progenitors Democritus, Descartes, Hobbes, Locke, Berkeley, and Hume, has at its root the engineer's model or machine with its atomistic and manipulable parts. Organicism is exemplified in the works of Hegel and his followers and elaborates a central imagery of organisms and biological specimens, process and growth. The fourth root metaphor that Pepper sees as having demonstrated its adequacy, contextualism, draws its central imagery from artistic endeavor, and it emphasizes the relationships between creative process and created product, foreground and background, form and content. It is most closely associated with the pragmatic movement and the works of Peirce, James, Bergson, Dewey, and Mead. Each root metaphor has survived in the competition with other metaphors (root and otherwise) in an effort to render the world comprehensible. Success in this competition depends upon the richness, as well as the coherence, of the vision the metaphor supports. These visions -- Pepper called them "world theories," correctly emphasizing their universality while imputing to them a tentative, conditional acceptance -- are, like paradigms in the largest sense of that term,[20] defined by the particular circumstance that they are organizing schemas to which no fact is irrelevant. Like paradigms, world theories not only explain phenomena, but also suggest further inquiries and researches that might be made, inquiries whose importance depends upon the perspective inherent in the theory. "World theories" are thus for Pepper "world hypotheses," also: their ability to organize successfully information across a broad range of experience is, as he sees it, continually being tested, as partisans of a particular root metaphor try to demonstrate its powers of generalization by assimilating old and new observations, facts, and phenomena to its structure.

But the language of "theory" and "hypothesis" is out of place here. Root metaphors are cultural, as well as philosophic, phenomena, and as such the realm of their popularity extends far beyond the circle of philosophers and "extraordinary" scientists who might, if they have read Pepper's book, be expected to hold them as tentative ontological propositions. In most of their uses (even in philosophy and science) root metaphors are more like sub- or semi-conscious articles of faith, and the process of assimilation of old and new observations and phenomena rarely endangers the firmness with which they are held. The competition between root metaphors occurs not so much in the minds of individuals as between groups of individuals who seek to leave the impress of their understanding, which has its origins in a particular root metaphor, upon events, affairs, experiences, and phenomena. If we were to extend Pepper's implicit evolutionary metaphor (the one suggested by the language of competition and survival) we might say that Pepper has mistakenly selected the individual, rather than the species, as the relevant unit in his vision of the struggle for existence between root metaphors.

And yet Pepper would not have us push that evolutionary imagery too far -- or, more correctly, push it much at all. Pepper is profoundly unconcerned with the possibility that there is an evolutionary logic to the invention, full development, and decline of root metaphors.[21] He presumes to examine root metaphors in some atemporal abstract, focusing, as a formist might, solely upon the structural and formal elements of root metaphor and ignoring entirely the manner in which the "fit" that obtains between a root metaphor and the world of experience is subject to the vagaries of history, change, and process. Because there is change and development in the world that the root metaphor comprehends and renders ordered, and because that world of phenomena changes in part because of human action undertaken within idea systems, there is a dialectical tension, a coevolution, between phenomena and root metaphor, world and idea, the thing explained and the explaining thing. Mechanism may well have been prefigured in Democritus' atomism, but certainly it came into its own as an architectonic vision and archetypal metaphor only with the invention and wide dissemination of machines. And, just as certainly, it achieved its greatest power of explanation only after humans came more and more to depend upon machines and so allowed their society to be shaped by the rhythms and "requirements" of the machine. Once admit that the competition between root metaphors takes place not in the abstract but in concrete, historical context, and the possibility is introduced that there is a discernible pattern in the successive elaboration of root metaphors through history, and in the eclipse of one by another.

The fact that root metaphors come into being, flourish, and are eclipsed means that there are grounds upon which people do in fact make choices between them -- although one must be aware of the existence of root metaphors if one is to make a conscious choice between them. One set of criteria for such choice can be developed from an understanding of what root metaphors do, of the "work" they do when they "work". As a first approximation, it is reasonable to expect that people choose the root metaphor that works best.

Pepper's description of what root metaphors do contains several criteria for judging whether particular root metaphors are or are not root metaphors, and because these criteria are matters of degree rather than absolutes, they can be turned into evaluative criteria. As Pepper has it, the successful root metaphor is "capable of generating theories with a high degree of structural corroboration," by which phrase he means an agreement between the theory and a broad range of fact.[22] It is a concept best understood through contrast to what Pepper calls "multiplicative corroboration," and through the example he gives. If we were to inquire into the strength of a chair, we might ask a number of people to sit on it; if it doesn't break, we would then have multiplicative corroboration for our hypothesis that the chair is sound. Structural corroboration occurs when, from an examination of the parts -- the woods used, the fastening devices, the overall design -- we infer that the chair is sturdy. Structural corroboration is "an agreement of many different facts in the determination of one central fact," and a "massiveness of convergent evidence upon the same point of fact"--evidence that has to do not with repeated trials of an observation but with observations lying beyond, but in relation to, the point of fact in question.[23]

Successful root metaphors also exhibit a high degree of precision in bringing together the diverse bodies of theory and observation that constitute that root metaphor's structural corroboration. It is not enough that the observations that form the structural corroboration be <u>consistent</u> with the perspective of the root metaphor; they must be capable of being seen as being _logically entailed_ by the perspective of the root metaphor. (This is of course a matter of degree; root metaphors, like paradigms, survive through _ad hoc_ repair, and beyond the realm of core theories and disciplines that are logically entailed by the root metaphor the best that one can hope for is that the range of theories and disciplines that are merely consistent with it will be as small as possible.) Thus, animism (one of the root metaphors that Pepper identifies as inadequate, and which takes as its central metaphor the human form) has a high degree of cognitive indeterminateness in explaining natural phenomena: within animism thunder could be explained as the voice of an angry spirit, or the result of a collision of spirits, or the product of any one of innumerable activities undertaken by a spirit or spirits. All of these explanations are consistent with the principles of animism; none can be said to be logically entailed. "There is no one precise and determinate interpretation of thunder, nor is there any precise method for finding one, nor is there any hope that more factual observation will ever produce one through these categories."[24]

Successful root metaphors are also "turned to cognitive uses," and thereby shape their holder's notion of truth. Formism suggests a correspondence theory of truth, in which the pictures, maps, diagrams, sentences, formulae and mental images we make are said to be true if they resemble or correspond to the object they are said to be true of in the appropriate, relevant aspects.

Mechanism depends on what Pepper calls a causal-adjustment theory of truth, which assumes a system of causal connections between environmental stimuli and the response of an organism, and in which truth is a name correctly applied to physiological attitudes which are in adjustment to the environment. Organicism employs a coherence theory of truth, in which the ultimate truth is the whole or absolute and in which any truths we achieve are likely to be partial, more or less coherent fragments of that absolute. Contextualism makes of truth an instrumental condition that allows us to achieve the ends we desire in our interactions and relations with the elements of our experience.[25]

These are characteristics of "successful" root metaphors -- metaphors that survive in competition with other root metaphors. These characteristics can be turned into criteria by which to judge root metaphors as "better" or "worse", but only in this limited sense: as criteria, they allow us to judge whether one root metaphor is better than another as an abstraction, *as root metaphor*, without reference to the ultimate purposes to which root metaphors are but instrumental means. And those ultimate purposes are by no means easily specified. Because root metaphors are characteristic of human thought, an answer to the question "what makes a root metaphor better or worse?" must involve an answer to the question, "what makes human thought better or worse?" And that question is unanswerable without reference to either or both of the questions, "What *is* the purpose of human thought?" and "What *should be* the purpose of human thought?" It is no large jump from recognizing this to recognizing that the attempt to answer the question, "What makes a root metaphor better or worse?" involves us in one of the perennial concerns of political philosophy, the question of the ultimate good for humans and the nature of the good life.

I will not presume to answer that question here. I will only note that the root metaphors themselves offer very little help in arriving at a clear answer to this question, because each root metaphor, as the defining element in a particular branch of thought within the western tradition[26], offers us a characteristic interpretation of politics and the life of the polis. Most of the philosophers whose names are associated with root metaphors are remembered as political philosophers, and this is no coincidence; it is through the esemplastic power of root metaphors that political philosophies "encompass disorder", illuminate, codify, and make intelligible the apparently random quality of politics-in-crisis. That political philosophies do this there is no doubt:

> ...most of the great statements of political philosophy have been put forward in times of crisis; that is, when political phenomena are less effectively integrated by institutional forms. Institutional breakdown releases phenomena, so to speak, causing political behavior and events to take on something of a random quality, and destroying the customary meanings that had been part of the old political world.... [Political philosophies] are evidence of a 'challenge and response' relationship between the disorder of the actual world and the role of the political philosopher as the encompasser of disorder.[27]

And that political philosophers turn to the esemplastic power of metaphor in order to accomplish this is equally beyond question:

> Since antiquity, politics has been regarded as a realm about which only probabilistic statements could be made. So thinkers have been driven to escape this realm, to find some sort of certainty in religion, cosmology, science, and so on, and carry it back into politics. But this is not necessarily a self-conscious escape. It may be that certain sorts of statements about the state--vivid descriptions of or bold assertions about its essential qualities--such as human beings are prone to make, simply cannot be made, cannot even be thought, except metaphorically.[28]

These statements together (the first from Sheldon Wolin, the second from Michael Walzer) suggest several things. First, that there is some relationship between what political scientists call the "efficacy" of institutions and the power, the currency, the sheer popularity of the root metaphor at the core of the world perspective upon which those institutions are founded. That relationship is not a simply causal one -- the "stabilization" or "destabilization" of institutions or regimes is probably not a function best performed by poets and purveyors of metaphor. Yet, there is truth in Shelley's dictum that "Poets are the unacknowledged legislators of the world," for a successful challenge to the root metaphor of a political society cannot help but have important effects on its social and political institutions and what is thought about them. (One clear instance of this has been studied by Martin Landau in his examination of the role that metaphor has played in American political analysis.[29])

Second, the popularity of a particular root metaphor may have less to do with its usefulness as an esemplastic concept than with the perceived source of authoritative knowledge within a culture. Thus, the ubiquity of a certain pattern of relational imagery within a culture may not be indicative that such a pattern has become that culture's root metaphor; it may signify the desire of thinkers within that culture to "carry back into politics" (or whatever other realm) a measure of certainty and authority borrowed from another, more apparently authoritative, field.

Third, these two quotations suggest that the ultimate answer to the question of whether a particular root metaphor is good or bad depends upon our judgment of the efficacy of the political institutions and forms that the metaphor supports. That efficacy can only be judged by measuring those institutions and forms against the normative ends they serve or ought to serve. The ambiguity here is unavoidable: it stems from two separate categories of criteria by which root metaphor may be judged. When we add to these two the category of criteria that were developed from our discussion of what root metaphors are, we have three broad ranges of criteria for evaluating root metaphors, which can be described as wholly internal or formal (is the root metaphor adequate in scope, precision, and internal coherence? Does it lead us where it, as root metaphor, says we ought to want to go?), instrumental (does the root metaphor offer a characteristic perspective that can explain existing social institutions, structures, and practices?) and normative (does the root metaphor offer a characteristic perspective consonant with social institutions, structures, and practices as they ought to be?). From this we can see that only when our normative judgment leads us to desire stasis -- only when we think that this is, in fact, the best of all possible worlds -- will the judgments resulting from the application of criteria in the second and third categories argee. Implicit in the foregoing are two characteristics of root metaphors and their relation to political change that deserve to be made explicit. Each root metaphor offers some sort of bridge over the fact-value or is-ought dichotomy, and a call for a structural or systemic change is a call for envisioning politics through the lens of a new root metaphor, or (in a different image) a call for making use of a different bridge between facts and values.

This is to say, fourth, that these quotations suggest that new root metaphors or new elaborations of existing root metaphors will be put forth in identifiable periods of perceived political crisis -- times when "political phenomena are less effectively integrated by institutional forms," times when old values no longer seem relevant to contemporary experience. We note here the possibility that entropy, as an idea whose central imagery concerns the relationship of order to disorder, and which suggests to many that chaos is the "natural" or logically prior and temporally inevitable state of affairs, may enjoy a special popularity as a sort of transitional metaphor, mediating a shift from one root metaphor to another.

This discussion has indicated the criteria by which we can judge whether the idea of entropy is an adequate root metaphor, and, if so, whether it is a good or bad root metaphor. In order to make these assessments, we need to know more about the idea of entropy; the chapter immediately following this addresses that task. Successive chapters will discuss the character of energy imagery as it has occured in different temporal and intellectual contexts: a chapter on Brooks Adams, his use of thermodynamic ideas, and the general tenor of energy imagery in the late nineteenth century will prepare the ground for our understanding of Henry Adams' particular (though implicit) criticism of entropy as an organizing idea; and in following chapters we will turn to extended discussion of more recent, more nearly contemporary uses of the idea. Finally, a concluding chapter will make explicit the judgments about energy imagery that our analysis leads us to.

It is important to note that the catalogue offered herein of energy imagery inspired by the laws of thermodynamics, and by the second law in particular, is by no means complete. The number of instances of such imagery, though finite, is enormous, and only a work much longer than this could presume to be comprehensive. And yet, fortunately, the majority of such instances are irrelevant to the task at hand; we will merely note in passing the breadth and ubiquity of energy imagery, while focusing attention on the more substantial employments the idea of entropy has found in the works of particular thinkers. Because those thinkers have written in widely different fields of knowledge -- and because tracking the idea of entropy through these widely different fields of knowledge is the whole <u>point</u> of discovering its status as root metaphor -- the task at hand lies beyond the expertise of any particular academic specialization. This should not become a reason for not undertaking this sort of enterprise, however. As Stephen Brush wrote in his book exploring the interconnections between thermodynamics and culture:

> Clearly it is quite difficult for any one person to learn enough about both the science and the culture of recent centuries to write this kind of history with much confidence. Nevertheless the attraction of the subject is irresistable, and one can always hope to learn something new from the protests of the experts upon whose domains [one] has encroached.[30]

Chapter Three

A SHORT HISTORY OF THE IDEA OF ENTROPY

> Where it is a duty to worship the sun it is pretty sure to be a crime to examine the laws of heat.
>
> John Morley

> Mayer at his own expense had printed various accounts of the work [he had done demonstrating the mechanical equivalent of heat,] that were either ignored or ridiculed. In them he propounded ideas such as, "The sun is our principal source of energy; animal energy comes from ingestion of plants which have stored the sun's energy; and the burning of fossil fuels releases the sun's energy as it was stored eons ago by decayed plant life." These ideas...were taken as further evidence of his madness.
>
> Donald W. Rogers

Among all the branches of physics, thermodynamics--the science of energy and its transformations--stands out as the main field of scientific revolution and development in the long years between the elaboration of Newton's mechanistic vision of the cosmos and the Quantum and Relativity theories of the early twentieth century. Thermodynamics also stands out because, more than any other branch of physics, it smacks of its anthropomorphic--its human--origins. This is enough for some misguided purists to relegate it to an inferior status in the pantheon of scientific inquiry.[1] But the anthropomorphism is inescapable: thermodynamics began, in the early part of the nineteenth century, in the study of heat energy and its more efficient use in steam engines, a subject of some economic importance as England (the country in which the Newcomen and Watt engines were developed and first put to wide use) suffered through a power shortage consequent upon its rapid industrial development.[2] Fundamental to thermodynamics is the distinction between useful ("free") energy and useless ("bound") energy--a distinction that is peculiar for being at once anthropocentric (use implies a user) and beyond the power of humans to affect or alter (no amount of wishing, no kind of apparatus or manipulation, can change the fact that energy which exists at or below the lowest temperature in a thermodynamic system is irretrievably lost to us). Far from being reason to relegate thermodynamics to the background among sciences, this peculiar mixture of the anthropocentric and the objective could be taken as a reason to elevate thermodynamics in status, to see in its laws the exemplars for all human knowledge. But whether or not we choose to take thermodynamics rather than Newtonian mechanics as the archetypal science, this much is clear: thermodynamics served as an important foundation for such later developments in physics as Heisenberg's uncertainty principle and Einstein's general theory of relativity, and for this reason alone it bears scrutiny and has earned a special status within the broader discipline of physics. Thermodynamics served as a bridge between mechanistic and modern physics, and many of the problems that prompted this change originated in, or had their clearest formulations in, thermodynamics.

As nearly any text on the subject will mention, the history of the idea of entropy begins early in the nineteenth century with a young French field artillery officer named Sadi Carnot, in whose work the bare outlines of the first and second laws of thermodynamics are visible. In 1824 Carnot published a monograph titled "Reflections on the Motive Power of Fire" in which he set out to clarify the principles upon which steam engines work. Some think that the first law is prefigured in Carnot's statement therein that "the production of motive power is...due in steam engines not to an actual consumption of the caloric, but to its transportation from a warm body to a cold body."[3] He obviously saw that heat--or caloric--is not destroyed or consumed, but is instead merely transferred. But in this, he was not particularly original; the received opinion of the day was that heat energy was indestructable, that caloric could be neither created nor destroyed. There is an irony in this widespread belief in the conservation of heat or caloric; all across Europe steam engines were busily converting heat into motion while physical theory denied that very possibility. It was not until the near simultaneous discovery of the principle of conservation of energy by Julius Robert Mayer and James Prescott Joule in the 1840's--a development that depended, in part, upon the more precise signification of the words "power," "work," "force," and "energy," and the demise of the caloric theory of heat --that heat and motion were understood to be two manifestations of energy, convertible one into the other.[4] Joule established the first law of thermodynamics--"energy is neither created nor destroyed, only transformed"--by conclusively demonstrating that heat had a mechanical equivalent, though Mayer had a valid claim to priority which was eventually recognized.[5]

While Joule succeeded in gaining public acceptance for the principle of conservation of energy, and Mayer was actually the first to give public voice to it, Carnot's journals show that he had doubts about the caloric theory and recognized that if caloric did not exist, heat and motion must be but two incarnations of the same thing. "Heat is nothing more than motive power that has changed its form," he wrote in a notebook. "Wherever motive power is destroyed...heat is produced in a quantity exactly proportional to the motive power lost; conversely, wherever there is destruction of heat, there is production of motive power."[6] That these statements, written sometime before Carnot's early death (at age 36, by cholera, in 1832), contradict the theory set out in his "Reflections..." explains, perhaps, why Carnot published no more after that volume in 1824. He had not the time to feel the full force of rejecting the caloric theory, nor to elaborate a new theory. As it is, the "Reflections..." was the premier document of a new science, and showed a great deal of originality in its execution (if not in its purpose and scope: Carnot set out to imitate a monograph his father had produced on water power).[7] Had he been able to follow it up with another work outlining a science of thermodynamics based on a kinetic, rather than a caloric, theory of heat, it might have been "much the same as if Gallileo had rounded off the Two new sciences by writing Principia mathematica and Opticks."[8]

The second law of thermodynamics is more clearly foreshadowed in Carnot's memoir than the first, although here too the caloric theory prevents it from taking a form similar to the one it took later, at the hands of Rudolf Clausius. Carnot saw that the amount of work that can be extracted from a heat differential increases with the difference in temperature, and that "the production of heat alone is not sufficient to give birth to the impelling power; it is necessary that there should be cold; without it, the heat would be useless."[9] These are important corollaries of the second law, for they amount to a statement concerning the impossibility of perpetual motion of the type ruled out by the law of entropy. With these words, Carnot states that the potential for work depends upon relative temperature differentials--a steam engine, for instance, could not operate in an atmosphere that is the same temperature as the incoming steam. If a steam engine could do that, it would be a perpetual motion machine, deriving useful work from the energy in the atmosphere that surrounds it, and exhausting its "spent" steam at a temperature identical to the temperature of that atmosphere.

In this way, then, Carnot's monograph contains the seeds of the second law. He seems to have arrived at these insights through observation shaped by an analogy to water power:

> In accordance with the principles we have now established, we can reasonably compare the motive power of heat with that of a head of water: for both of them there is a maximum which cannot be exceeded, whatever the type of hydraulic machine and whatever the type of heat engine employed. The motive power of a head of water depends upon its height and the quantity of water; the motive power of heat depends also

> on the quantity of caloric and on what may be called--what we shall call--the height of its fall, that is on the temperature difference of the bodies between which the caloric flows.[10]

But the analogy to water power could not carry him to a clear statement of the second law, for at that time the hydrological cycle--the great engine driven by the evaporative powers of the sun, whose power was most obvious in the kinetic energy of falling water in rivers and streams--was not at all understood.[11] As long as the ultimate source of the power of water wheels and mills was not understood, the analogy to water (an analogy that would have had a great deal of force for those who believed in caloric as an invisible, elastic fluid) led away from the insight that the energy sources of the planet are not infinite.

We can hardly fault Carnot for not coming up with a clearer statement of the law of entropy, even in a work remarkable for being perhaps "the most efficient piece of abstraction in the history of science."[12] His failure to do so is a product of his fealty to the analogy to water power, the lack of clarity of the language available to him ("*vis viva*," "motive power," "tension," and "energy" were ill-defined and loosely synonymous), and his own limited aims: he sought not to create a science of heat, but achieved that only as a byproduct of fulfilling his desire to offer his compatriots an introduction to the principles of the steam engine. His purpose was less scientific than technical, his concern less for the advancement of science for its own sake than for the education of designers and prospective owners of steam engines, his spirit less ecumenical than nationalistic: he wrote for the entrepreneur who felt called "to direct, to co-ordinate the labors of his fellow men [sic], to make them co-operate towards a useful end, whatever that end might be," knowing full well that whatever that end might be, the more efficient use of steam power in its pursuit would serve the interests of France.[13] "Reflections..." begins with a panegyric to the industrial strength of steam, during which Carnot casts a jealous eye across the English Channel:

> Iron and heat are, as we know, the supporters, the bases, of the mechanical arts. It is doubtful if there be in England a single industrial establishment of which the existence does not freely employ them. To take away today from England her steam engines would be to take away at the same time her coal and her iron. It would be to dry up all her sources of wealth, to ruin all on which her prosperity depends, in short, to annihilate that colossal power.[14]

To a young man whose father had been one of Napoleon's most successful generals, that prospect might have had a certain special appeal. We can trace the concept of entropy, then, to the quest for improved industrial efficiency prompted by the nationalist hopes of this young French artillery officer and amateur physicist.

The second law of thermodynamics received its first clear statement in the work of the German physicist, Rudolf Clausius. In 1850 he cast the law in the form of a statement concerning the impossibility of perpetual motion: "It is impossible for a self acting machine, unaided by any external agency, to convert heat from one body to another at a higher temperature."[15] Four years later he reformulated the law by coining the term entropy:

> I prefer going to the ancient languages for the names of important scientific quantities, so that they may mean the same thing in all living tongues. I propose, accordingly, to call [this quantity] S the entropy of a body, after the Greek word 'transformation.' I have designedly coined the word entropy to be similar to 'energy,' for these two quantities are so analogous in their physical significance, that an analogy of denomination seemed to me helpful.[16]

Entropy as Clausius understood it was the amount of heat energy in a closed system that exists at or below the lowest temperature in the system; it is degraded energy, unavailable for work, for it has already "fallen" to the lowest level. The concept of entropy thus allowed Clausius a succinct statement of the second law of thermodynamics: "The entropy of the universe tends toward a maximum." By deriving the term through an analogy to "energy," Clausius might have hoped to suggest that this principle represented no grave threat to the mechanist conception of heat that had replaced the earlier caloric notion. If heat energy were ultimately reducible to motion, to an agitation of molecules, and energy was conserved, why then should it be consumed in work? Where does the motion "go"? Clausius' analogical derivation of the term tended to paper over the fact that the first and second laws of thermodynamics, unlike Newton's laws of motion or Euclid's axioms of geometry, are not derivable one from the other; they are about fundamentally different things. "The first law states an ideal equality, and the second a real inequality;" the first law derived from a concern for the convertibility of different forms of energy--which is to say, reversible processes--and the second law from the experience that in such transformations some energy is lost to us, irrevocably and irreversibly.

In the mid-1800's, physics was still firmly grounded in Newtonian mechanics, and the notion of an irreversible process was novel--even, perhaps, heretical. In the formulae of classical mechanics, it hardly mattered whether time were present as T or -T; the equations held either way, for all purely mechanical processes are reversible in time. (An earth or a solar system that rotates in a direction opposite to ours does not violate any mechanical principle; a movie of a purely mechanical process--such as the inner workings of a gearbox--would offer no clues as to whether it was being run forward or backward.) The idea of entropy challenged the elegance and comprehensiveness of the Newtonian system (and it was the first such challenge that classical mechanics encountered). To those who believed, along with Lord Kelvin, that the human mind can comprehend only those phenomena that it can model or explain in mechanical terms, Clausius' formulation of the law of entropy challenged the entire edifice of human knowledge by pointing up a range of phenomena that fell completely and awkwardly outside its scope.

The anomolous nature of thermodynamics presented a challenge that drew the attention of many physicists, including the young Ludwig Boltzmann. In 1866, at the age of 22, he wrote a paper "On the Mechanical Meaning of the Second Law of Thermodynamics," which was the first serious attempt to bring a mechanist foundation to the law of entropy. While this early work falls short in its attempt to explain irreversible processes by reference to molecular activity, by 1877 Boltzmann appeared to have solved the problem.[17] His contribution was to conceive of entropy not as a quantity of energy irretrievably lost within a thermodynamic system, but as a measure of the degree to which the kinetic energy of individual molecules in a system approached the average kinetic energy of the molecules in that system. The desired mechanist base was obtained, but only at the cost of introducing the relative uncertainties of probability theory--a price that was thought to be too high by many of Boltzmann's contemporaries.

Boltzmann began with the kinetic theory of heat, reasoning that if heat were the result of an agitation of molecules, then a heat differential (and a potential for work) must mean that some identifiable part of the molecules in a thermodynamic system are moving relatively rapidly, and some part of them are not. The two kinds of molecules are segregated--fast ones <u>here</u>, and slower moving ones <u>there</u>--and we say that the system has a low entropy. If we imagine that the molecules are molecules of a gas, we can see that the segregation will be short lived; the natural tendency of the molecules will be to mingle and to impart their kinetic energy to each other through collision until all the molecules have the same kinetic energy--or, alternatively, until the average kinetic energy of the gas comes to prevail in each part of the container it is being kept in. (The molecules of a solid impart their kinetic energy to each other primarily through collision, not being as free as gas molecules to move about and mingle.) If the average kinetic energy obtains throughout the gas, then the energy differential (and the potential for work) is gone and the gas has a high degree of entropy. If we assume that the container is perfectly insulated (so that no kinetic energy can be lost through the imparting of motion to the molecules in the wall of the container), there can be no further rise in the entropy of the gas (and no further change at all within the container).

Boltzmann discussed this process in terms of a distinction between _micro-_ and _macro-_ states of the gas. The micro state referred to the many possible arrangements of the molecules of the gas; the macro state referred to the overall measure of the entropy of the gas. For a given entropy, there were a corresponding number of possible micro states. For the lowest entropy, there was only _one_ possible micro state: all the high energy molecules _here_, and all the low energy molecules _there_. For macro states of successively larger entropy, there were successively larger numbers of possible micro states, up to the highest possible entropy, which could be achieved by any one of the largest possible number of micro states. Since there are more ways to achieve a higher entropy than a lower one, a higher entropy state is more probable.

In this manner, entropy became a statistical law, a law of probability. "If...in a given system of bodies there is a given amount of energy, the latter will not arbitrarily transform itself now in one, now in another manner, but it will always go from a less to a more probable form."[18] The more probable form is an homogenous one; and, since work can only be accomplished by using energy differentials, "precisely those forms of energy that we wish to realize in practice are...always improbable."[19]

The law of entropy also became a law of disorder through Boltzmann's formulation, and that fact may betray the preferential place given in western culture to the human ability to draw distinctions over the ability to detect similarity. The low entropy state is marked by a sharp segregation of low- and high-energy molecules, and that segregation is taken as a degree of order. The law of entropy is now commonly understood to be at work in any physical process in which the segregation of entities into coherent groups breaks down, and a "random", "homogenous" distribution comes to prevail. We need only substitute the word "integrated" for "homogenous" in order to suspect that a hint of prejudice underlies this connotation of the entropy law. To the entropy law, it hardly matters whether the molecules it describes are those of a gas, in which some have a greater and some a lesser kinetic energy, or those of two fluids (of equal temperature), one colorless and one a tiny drop of color; their co-mingling proceeds spontaneously, and can only be halted or reversed by the importation of energy. For us to call one state ordered and the successive states disordered, however, seems arbitrary. The principal that maximizing differentia is the path to highest order is belied by a great deal of human experience, including political (which shows that differences are sometimes best ignored if order is to prevail), transcendent-mystical (in which some of us detect an order in the cosmos or in nature by perceiving its oneness) and practical (in a holograph, each part contains the image of the whole, and is nonetheless ordered). We would be foolish on this count merely to affirm the negative of the premise implied by entropy and say that order is found in conflating differentia into an image of oneness. The mind is capable of detecting order in anything it can comprehend, and it does this sometimes by detecting unity and sometimes by detecting difference. The entropy law as Boltzmann formulated it both assumes and has been adduced as support for the view that the path to order lies solely in endeavoring to keep like with like, apart from unlike, and this view has some profound implications for how we view ourselves and our world.

In providing the second law with a mechanistic base, Boltzmann seemed to salvage the unity of physics while filling a gap in the Newtonian framework. Newton's physics was not only time variant, it could offer no explanation of time whatsoever, relegating it to the status of a subjective perception. (Some physicists even speculated that on other planets or in other solar systems, time might move in a direction opposite to that which we experience.) With Boltzmann's probabilistic explanation of entropy, time could be justified as the objective, inexorable march of the universe toward maximum entropy; entropy was, in Eddington's phrase, "time's arrow." But the appeal to probability theory--that peculiar device through which order is perceived in chaos, and which depends upon human ignorance in the very process of circumventing it--made Boltzmann's work controversial. Max Planck, who later accepted statistical thermodynamics, expressed doubts about entropy becoming only probabilistic; in Boltzmann's vision, he thought, entropy could conceivably decrease, and this meant that the second law would not be "as general and free from exception as the law of conservation of energy."[20] By far the heaviest criticism came from Ernst Mach and his followers, who in the 1880's were mounting a campaign against mechanism in science. As positivists, they were out to purge physics of such "metaphysical" concepts as atoms and molecules--and, indeed, of all mental images and hypotheses.[21] Ironically, Mach--one of the founders of the Vienna Circle of logical positivists--counted Boltzmann, an "old guard" atomist, as one of his early influences; ironically, because Mach never did accept the atomic theory as anything other than a fiction useful only insofar as it brought predictive accuracy, and because criticism from Machian "phenomenologists" was a contributing factor in the depression that ended, for Boltzmann, in suicide in 1906.[22]

From statistical mechanics as Boltzmann articulated it there flow two lines of intellectual development that have shaped the twentieth century; this, despite the fact that there is good reason to balk at a theoretic approach that tells us, in effect, that if we have not seen the dead rise again and walk, or ashes spontaneously reconstitute themselves into usable coal or wood, or tea cups levitating, it is not because these phenomena are by their natures impossible, but because we have not (and most likely will never) observe a sufficient number of cases. The probabilistic nature of statistical mechanics did not prevent it from eventually gaining acceptance and playing a crucial role in both the foundation of the science of information theory and the work of Albert Einstein.

We can trace the origin of information theory to a paradox in the kinetic theory of gases articulated by James Clerk Maxwell, a contemporary of Boltzmann's. The paradox was presented by Maxwell as an almost parenthetical aside toward the end of his textbook, the Theory of Heat, in 1871. Maxwell began with the fact that in any quantity of gas, some molecules have more kinetic energy than other molecules. He asked his readers to conceive of "a being whose faculties are so sharpened that he can follow every molecule in its course," and to imagine that this creature operated a frictionless door in a bulkhead that separated two volumes of gas, A and B. Suppose that the volumes of gas in A and B are at the same temperature and pressure; and, further suppose that the being,

> who can see the individual molecules, opens and closes the hole, so as to allow only the swifter molecules to pass from A to B, and only the slower ones to pass from B to A. He will thus, without expenditure of work, raise the temperature of B and lower that of A, in contradiction of the second law of thermodynamics.[23]

The "sorting demon," or "Maxwell's demon" as it also came to be known, does seem to violate the second law by creating an energy differential where there had been none before. The demon was to become the focus of debate that lasted nearly a century. Physicists quickly realized that the deeper implications of Maxwell's nearly offhand remark required rigorous theoretical refutation; it would not do merely to assert that such a miniscule creature was unknown, unlikely, or impossible. The demon could be seen as a particular type of semi-permeable membrane, and if it could not be shown that such a membrane was impossible, then the possibility existed that intelligence could somehow overcome the second law in the affairs of the world. As P. G. Tait stated in 1880: "Had we the means of dealing with the particles individually, we could develop on a large scale what takes place continuously on a very minute scale in every mass of gas: the occasional, but ephemeral, aggregation of warm particles in one small region and of colder in another."[24] As physicists sought to determine whether such a demon was possible, several important ancillary discoveries were made. The development of the discipline of information theory is one such direct result of the quest to resolve the problem represented by Maxwell's demon.

In 1929, Leo Szilard published a paper "On the Reduction of Entropy of a Thermodynamic System Caused by Intelligent Beings." Szilard's paper redefined the issues involved in the problem of Maxwell's demon, and provided a clear direction for further inquiry into the matter. Szilard pointed out that the demon could only confound the second law through the operation of information gathering and memory retrieval capabilities. If information about the disposition of molecules in a sealed chamber could be gained and stored with no increase in entropy (or no expenditure of energy), then that knowledge could be used in a way that reversed the entropic processes in the chamber. Szilard concluded: "If we are not willing to admit that the second law is violated, we have to...[demonstrate] that the action which... establishes the 'memory' is indissolubly connected with the production of entropy."[25]

Szilard's work thus provided the opening that led to the development of information theory. As it was later developed by Norbert Wiener, Claude Shannon, Warren Weaver *et al*., information theory added a new dimension of meaning to the word "entropy." Shannon discovered that Boltzmann's equation for entropy was also the equation for the average information per symbol in a message. Information theorists themselves seem to be unsure whether this identity is mere coincidence or whether the two concepts bear some other, more essential relationship to each other. One suggests that the identity has its origin in the statistical nature of the two concepts: "Information is news: what is known already is no information. So something is information to the extent that it is unknown, unexpected, surprising, or: improbable."[26] Since the increase of entropy is probable, and information is not, this would suggest that the two ideas have a complementary relationship to each other. But this is not quite the case. As Weaver puts it: "for a communication source one can say, just as he [sic] can say of a thermodynamic ensemble, 'this situation is highly organized, it is not characterized by a large degree of randomness or choice

--that is to say, the information (or the entropy) is low.'"[27] This clearly relates the two terms directly, rather than inversely, by suggesting that a measure of entropy is a measure of information. (Elsewhere Weaver speaks more cautiously of the "entropy-like expression" which measures information, indicating his own disquiet with the similarity between the two terms.)

Part of the confusion surrounding the idea of entropy as it is used in information theory stems from an ignorance of the special meaning that the term "information" carries in this field. It is a confusion to which information theorists themselves contribute when they speak simplistically of information as news; information is <u>not</u> news, for information has nothing to do with meaning. The term "information" refers instead to the amount of discretion one has when selecting a message, not to the content of a particular message.[28]

While information theorists took as their main task the resolution of problems in computer design and electronic communication (and, along the way, sharpened the teeth of their infant discipline by helping to make anti-aircraft fire more effective in World War II[29]), the problem that inaugurated the field was not forgotten. In 1951 Leon Brillouin published an article in which he purported to demonstrate that Maxwell's demon could not operate. He did so by elaborating on Szilard's speculation that information gathering and storage used more energy than could possibly be recaptured through intelligent use of that information. Brillouin's argument relies on the necessity of providing the demon with some sort of "spotlight" with which to see the molecules--an energy transmission medium capable of carrying information. The demon needs a great deal of information if it is to sort successfully all the molecules in its chamber; the number of highly improbable messages that would provide this information result in an entropic diffusion of energy that is greater than the energy the demon could recover through its efforts. Where the information medium is light (the case that Brillouin examined), the photons are reflected until they are eventually absorbed by the walls of the demon's chamber, its body, and its eyes, thereby diffusing their energy throughout the thermodynamic system. Several photons are needed to guage successfully the velocity of each molecule; the amount of energy gained never recoups this intial expenditure.[30]

Brillouin's argument was taken as a final reaffirmation of the second law, even though it is flawed by a fundamental circularity. In arguing for the necessity of a photon lamp, Brillouin relied on the principles of light as they had been enunciated by Gustav Kirchoff in 1859. Kirchoff, however, had assumed the validity of the second law in establishing that visible radiation becomes, inside a closed container, homogenous and non-directional, and therefore incapable of supporting sight.[31] In the absence of any observations that explicitly contradict Kirchoff's work, though, most scientists have accepted it as valid; and, until such time as Kirchoff's principles are seen as having been violated, scientists seem willing to forgive Brillouin his circularity and to accept the second law as valid. Thus, it was only as recently as 1951 that scientists could, with theoretical justification, view the counter-entropic actions of Maxwell's demon as being impossible.

The other main development that stemmed from statistical thermodynamics was the work of Albert Einstein; "all of ...[his] boldly original attacks on what he saw as the critical problems of early-20th-century physics are intimately related to his understanding of thermodynamics."[32] While a full-fledged discussion of Einstein's theories is somewhat off our subject, a brief review of how they grew from his concern with thermodynamics should serve to reinforce the notion that thermodynamics--and specifically, entropy--was at the center of much of the intellectual ferment in physics in the early part of this century.

Thermodynamics entered into Einstein's work in three distinct ways. First and most obvious is the way that several of the problems that the young Einstein took up either had to do directly with thermodynamics or were generated from that science. In a series of three papers published between 1902 and 1904, he explicitly set out to provide an adequate foundation for thermodynamics by attempting to derive its laws from the principles of mechanics and the theory of probability--ground already covered by Boltzmann (whose work Einstein was not fully familiar with, having had it only through Boltzmann's less detailed _Lectures on Gas Theory_) and J. Willard Gibbs (whose work Einstein did not know at all).[33] In 1905 he published four papers in the _Annals of Physics_--three in the now rare (and valuable) volume 17--one of which explained Brownian motion, a phenomenon that had troubled theorists for its apparent violation of the second law. (In 1827 the botanist Robert Brown had discovered that tiny grains of pollen, when viewed through a microscope, were in constant motion. He discovered that this motion afflicted particles only below a certain size, but could offer no explanation for the phenomenon. In "On the Motion of Small Particles Suspended in a Stationary Liquid According to the Molecular Kinetic Theory of Induction," Einstein explained this "never diminishing motion" by reference to the kinetic theory of matter and heat: the particles move because they are small enough to have their inertia overcome by the random impacts of individual molecules of the fluid in which they are suspended.) One could, along with Ronald W. Clark, characterize all of Einstein's work up until his "photoelectric effect paper" (which also appeared in volume 17 of the Annals) as being specifically about thermodynamics and statistical mechanics.[34] But even this revolutionary paper--which is about much more than the photoelectric effect--is embedded in Einstein's concern with thermodynamics, and in it we begin to see the second way in which that science was crucial to his intellectual development.

In this paper Einstein advanced the notion that light could be considered a collection of independent particles (or quanta) of energy, behaving like particles of a gas--"a suggestion that seemed a wanton dismissal of a century of evidence for the wave theory of light."[35] Einstein dismissed the wave theory of light not merely in order to explain the photoelectric effect (that was a happy byproduct) but to resolve a problem of much larger scope: the "profound formal distinction" or contradiction he saw at the heart of physics at that time, the unresolved tension between the electromagnetic theories of Maxwell and Faraday, on the one side, and the material particle essential to Newtonian mechanics, on the other. Both were essential to the conceptual structure of physics, it seemed, and they contradicted each other. The contradiction was manifest as an inability to explain satisfactorily what Paul Ehrenfest dubbed "the ultra-violet catastrophe:" the fact that the radiation of light produced by heating a black body to incandescence could be described by one set of formulae at low wavelengths and by a different set of formulae at higher wavelengths --"as though nature had changed the rules of the game at half time."[36] The black-body radiation was achieved by using a container, painted black inside, with a tiny pinhole through which light could escape. Einstein's path through the contradiction was suggested to him by his familiarity with thermodynamics and specifically through reasoning analogically from the law of entropy as it applied to gases. He first demonstrated that the entropy of radiation of a given frequency produced by heating such a black body depends on the volume of the enclosure in exactly the same way that the entropy of an ideal gas depends upon its volume. "This gave him the assurance to take the next step, the great leap: _if_ the entropy of radiation has the same form as that of a gas, and *if* the entropy of a gas has that form *because* it consists of independent particles, *then* radiation too must consist of independent particles."[37] Thus, by reasoning from an analogy grounded in his understanding of entropy, Einstein took the first step toward articulating a unified foundation for physics--a pursuit that led him, ultimately, to his development of the special and the general theories of relativity.

The third way in which thermodynamics infused Einstein's thought has to do with his belief that such a unified foundation was even possible, and his belief that it was possible to so recast Newton's laws of motion that they would no longer depend upon the vantage point of a "privileged observer." Einstein understood thermodynamics to be different from other general physical theories; he called it a "theory of principle" as opposed to a "constructive theory." This latter type, as he understood it, was a theory that attempts "to build a picture of complex phenomena out of some relatively simple propositions," while the former starts from "empirically observed general properties of phenomena" and reasons, through deduction, to results "of such a kind that they apply to every case which presents itself" without making any unnecessary assumptions.[38] If this distinction sounds like an obscurantist attempt to present the rather elementary distinction between inductive and deductive reasoning, that is less important than the fact that Einstein found in the example of thermodynamics a "theory of principle," the validity of which seemed to transcend its representation through particular models. Caloric could be challenged, or yet for that matter the kinetic theory of heat, and yet the impossibility of perpetual motion remained a fact. "A theory is the more impressive," he wrote, "the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability. Therefore the deep impression that classical thermodynamics made upon me."[39] He was confident that its basic concepts would never be overthrown; he aspired to create another such theory of "universal content" modelled after it. And, just as thermodynamics left aside questions concerning the structure of matter and instead gave a systematic answer to the question "What must the laws of nature be like so that perpetual motion is impossible?", Einstein sought to find out what the laws of nature must be like if the speed of light is to appear to be constant no matter what reference system the observer is located in.[40]

This brief introduction to the history of the idea of entropy has, for the most part, not looked beyond the human activity of science in recounting the role that the idea has played. Like many another idea from science, the idea of entropy has found widespread application beyond its original discipline. To recount <u>that</u> story, to catalogue and criticize all of the many and varied uses of the idea in fields far removed from thermodynamics, would require a volume dedicated to no other purpose. For the most part, we will ignore those other uses entirely, or relegate discussion of them to notes, even though those uses, too, are as much a part of the history of entropy as the specifically scientific theorizing it has influenced. Such uses do, however, demonstrate the tendency we humans have to pursue a sort of law of conservation of intellect, a first law of conservation in the economy of the mind: we borrow a powerful idea from one realm of discourse and turn it to account in other, widely different realms. The effect is, sometimes, a sense of unity; but the unity is often purchased only at cost of an unrecognized absurdity and a procrustean injustice.

Images aren't arguments, Henry Adams knew, and rarely lead to proof, but the mind craves them. We will begin a survey of how the idea of entropy has been used as an image within a variety of fields with an examination of how the idea of entropy was used by the brothers Adams in their "scientific" historical works. The next chapter looks at energy imagery in Brooks Adams' _Law of Civilization and Decay_ and discusses similar uses of energy imagery by some of his contemporaries. The following chapter is devoted to how the elder Adams brother voiced his dissent from that imagery in the very act of using it to criticise the burgeoning modernity of his day.

Chapter Four

BROOKS ADAMS AND THE METAPHORIC ALLURE OF THERMODYNAMICS IN THE LATE NINETEENTH CENTURY

In the last decade of the nineteenth century, the laws of thermodynamics captured the imagination of a broad segment of the thinkers and writers of the day. In retrospect it is unsurprising that a science as radical in its implications as thermodynamics should have done so. This young science was already revolutionizing and unifying "the study of chemistry, heat theory, heat engines, radiation, electricity, and magnetism"[1] -- and, in the process, bringing reknown and status to the men who applied it as a theoretical perspective. It was also provoking "less respectable, but nevertheless real,...far-reaching deductions, discussions, and speculations regarding the significance of thermodynamic concepts in cosmological works dealing with the source of the sun's energy, the origin of the solar system, and views on the expanding and contracting universe."[2] The power of thermodynamics as an authoritative science at this time was so firmly established that Eddington's words, though written some decades later, would not have been contradicted:

> The law that entropy always increases...holds, I think, the supreme position among the laws of nature. If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations -- then so much the worse for Maxwell's equations. If it is found to be contradicted by observation -- well, these experimentalists do bungle things sometimes. But if your theory is found to be against the second law of thermodynamics, there is nothing for it but to collapse in deepest humiliation.[3]

The novelty and the status of thermodynamics contributed to the enthusiasm with which it was applied beyond the confines of the science of physics. In the psychological works of Gustave Theodore Fechner, Johann Friedrich Herbart, Heinrich Sachs, Josef Breuer, and Sigmund Freud, various simulacra of the laws of thermodynamics make appearances and are turned to account in explaining mental processes[4]; in the great nineteenth century debate on the relationship of science and religion, the laws of thermodynamics entered the lists on both sides, being used by both those who sought to further and those who challenged religious belief[5]; in geology, paleontology, in the great debate on evolution, the laws of thermodynamics served as unimpeachable principles which an argument could ignore only at peril, and as ultimate arbiters of the correctness of theories.[6]

Such uses of the ideas of thermodynamics are sufficient to establish at least a prima facie case for the assertion that thermodynamics was at this time becoming a root metaphor. But in order for thermodynamics to have become a root metaphor, the ideas and concepts central to that science would not only have to be in some sense "popular," but also they would have to have been used in particular ways -- as esemplastic, world-ordering ideas. And in fact, this was the case. Thinkers were drawn to the laws of thermodynamics not only because of entropy's novelty and status, but because in the laws of thermodynamics they saw possibilities for coherent explanation, simplicity and elegance. Wilhelm Ostwald, for instance, found in thermodynamics a potential means for bringing all manner of phenomena under the scrutiny of a single, overarching theory. Others discerned in the laws of thermodynamics the possibility of comprehending human affairs in a new, more rigorous fashion, and thus of making social _studies_ into social _sciences_. Such a thinker was Brooks Adams, who, like a few other notable thinkers of his time, applied the ideas and conceptual language of thermodynamics to humans and human affairs in an effort to achieve a precision and an exactitude of knowledge consistent with scientific explanation. His major work, _The Law of Civilization and Decay_, was an ambitious attempt to read the history of Western civilization through lenses suggested by thermodynamics.

The historical circumstances in which Brooks composed the _Law_ give creedence to Wolin's perception of the political philosopher as the encompasser of disorder. Although the germ of the work lay in Brooks' earlier volume on _The Emancipation of Massachussetts_,[7] which appeared in 1887, and although the researches for the _Law_ were by and large complete by the summer of 1893, the character of the work as a whole was undeniably shaped by the author's experience of the Panic of 1893.[8] That summer brought the worst recession that America had to that date seen, with unemployment mounting to twenty percent of the work force and each day bringing news of yet another bank failure or industrial closure. The details of the Panic need not concern us here; it is sufficient to note that the economy of America suffered from a constricted money supply, so that prices in general were falling, and that this deflationary pressure exacted its greatest toll, as it must always, among the debtor classes: those unfortunates who found themselves paying back relatively more valuable dollars for monies they had borrowed, and spent, when prices were generally higher and the dollar consequently less valuable. The constricted money supply, and hence the recession, had been brought about by a Treasury policy designed to encourage the accumulation of gold bullion, which the government would need in order to implement a policy of re-establishing the free convertibility of paper into gold at the rate that obtained in the years before the civil war -- a policy that the administration of Grover Cleveland thought desirable. This required American prices to be lower than the already depressed (and generally declining) prices of Europe, so that Eurpoeans would find it profitable to import more American goods, with the imbalance in trade being righted by an American accumulation of gold.

The stock market panic of that summer, which was in part precipitated by this tight money policy, was just one manifestation of an economic and political situation that fully deserves the name of crisis. That crisis was most sharply portrayed in the confrontation between "silver men" -- those who favored the resumption of coinage in silver, at an exchange ratio of sixteen ounces of silver for an ounce of gold -- and "gold bugs" -- generally, bankers and wealthy capitalists, the "Eastern money interests" of the day, who profitted handsomely from the conditions of tight money. The silver party was populist in appeal and origin, and their diagnosis of the country's economic ills was essentially correct. The gold bugs, for their part, wished to "stay the course" in order to restore a financial and economic status quo ante. It is difficult for those unfamiliar with the period to gain a sense of the intense emotions that attached to this issue; gold and silver became symbols of completely different visions of America's future at an historical moment of great change, and the passions that attached to them were passions stirred by the larger changes at work in America.

Most of those changes had to do with America's coming of age as an industrial power. The confrontation between capital and labor came to a head in the Pullman strike of 1894, during which the national guard were called in to restore order. Sharply diverging visions of the government's role in regulating corporate activity lay behind the continuing controversy of the Sherman Anti-Trust Act, which had been passed in 1890 to less-than-unanimous acclaim. Some among the partisans of silver suspected that the Panic of '93 had been engineered by financiers and capitalists as a means to gain the Act's repeal -- a suspicion that, whether founded or not, indicates the level of polarization of belief that had taken place. The decade of the 1890's also brought the first stirrings of a maturing mass politics, manifest both in the Populist Movement, which rallied around William Jennings Bryan and the call for Free Silver, and in the Presidential election of 1896, during which Marcus Alonzo Hanna pioneered modern election techniques by "advertis[ing] McKinley as if he were a patent medicine."[9] America at this time also began to face the first intimations of its own finitude; the West had been settled if not completely tamed, denying to the American imagination any easy recourse to continued expansion as a cure for social, political, and economic woes.[10] The growth of a native conservation movement indicated a growing recognition of some sense of limit, and consequently of a change in the very foundations of American life.[11]

It is no exaggeration, then, to say that at this time the American polity faced a sea change. Rapid urbanization and industrialization of the country had wrought enormous changes, and these brought with them experiences that were unintelligible within the old categories and explanations. This experience was by no means uniquely American; throughout Europe, a similar sense of crisis, rooted in the breathtaking pace of change, prevailed. One may find evidence of the change nearly wherever one chooses to look: in the statistics on demographic trends (the 1871 census in Germany had recorded only eight cities of over one hundred thousand inhabitants; by 1900, there were thirty-three); in figures on the production of steel (in 1850, world production was eighty thousand tons; by 1900, it was twenty eight million); in the facts of industrial concentration (in the twenty-five year period centered on the decade of the 1890s, that is, from 1880 to 1915, the number of industrial plants in Germany employing five or fewer workers was halved, while the number of those employing more than fifty doubled); even in the figures on the sale of canned goods (four hundred thousand cases world-wide in 1870; fifty five million cases in 1914).[12] "When we seek to pinpoint the structural changes which lie at the roots of contemporary society," writes one historian, "we are carried back to the last decade of the nineteenth century; and there we come to a halt."[13] Those structural changes brought about the full development of European imperialism in the partition of Africa, and a consequent integration of world economic and financial affairs on a scale theretofore unimagined. No longer could financial panics or economic recessions be confined to single countries: the American Panic of 1893 was part of "the world-wide depression of the 1890s."[14]

The structural changes in national industrial economies and the first glimmer of an international economic system combined to produce a sense that the economic world was beyond the control of the managerial power of individual nations, let alone of individuals within those nations. The rapid pace of industrial development could not help but have an impact on social and political relations, and there the effect was much the same. The figures on industrial development are darkly mirrored in the figures on voluntary death collected by French sociologist Emile Durkheim for his epochal work, Suicide: A Study in Sociology. By 1897, the year that Durkheim published this work, it had become difficult to ignore the darker side of industrial development, its cost in human terms. "If...industrial or financial crises increase suicides," Durkheim concluded and warned,

> this is not because they cause poverty, since crises of prosperity have the same result; it is because they are crises, that is, disturbances of the collective order. Every disturbance of equilibrium, even though it achieves greater comfort and a heightening of general vitality, is an impulse to voluntary death. Whenever serious readjustments take place in the social order, whether or not due to a sudden growth or to an unexpected catastrophe, men are more inclined to self destruction.[15]

In asking himself, "How is this possible?", Durkheim was led to formulate his concept of <u>anomie</u> -- a state of normlessness, brought about when society, in a state of transition, can no longer exercise its regulating function on the appetites and conscience of the individual.[16] The diagnosis was born of the experience of the 1890s, which saw the culmination of "forces released suddenly and with revolutionary effect within the life span of one generation," as Geoffrey Barraclough put it.[17] That entire generation, Brooks' brother remarked, had had notice to quit; their ideas were tired, their experience irrelevant. Such was the state of Western culture when Brooks Adams settled down in his father's house in Quincy in order to "digest the chaos in my mind."[18] That chaos was formed of nearly equal parts of the data of his historical researches and the then-current crisis conditions of American -- and European -- life. Within and out of this chaos, <u>The Law of Civilization and Decay</u> took shape.

When it was published in 1895, the book was received in some quarters as a "free silver squib", though Brooks was at pains to avoid any obvious sermonizing about the American experience. He even went so far as to have the book published first in England, in the hopes that there it might be far enough removed from the passions of the day to be accorded a treatment appropriate to a serious work in the philosophy of history. Even so, he could not resist being pleased at its importation to this country, where it soon became caught up in the bitter Presidential campaign of 1896. With characteristic prescience, Henry had, upon reviewing the manuscript, pronounced it a sound attempt at a theory of history but then warned his brother not to publish: "I know not if you have any political or other ambition, but this will be their death blow. The gold bugs will never forgive you. You are monkeying with a dynamo."[19]

What the gold bugs would find objectionable in the _Law_ was the implication that finance capitalists are the agents of decline in any civilization. According to the _Law_, societies pass through stages or phases in a cyclical movement. The earliest stages are marked by a lack of cultural energy, which exists only as a potential, waiting to be brought together. The society is diffused geographically, with few, if any, centers of power and influence. Fear is the ruling human emotion, and is manifest in a celebration of military virtues, in the power of religious ideals and faith, and in the vitality of the culture's arts. As the society develops, it centralizes -- and its degree of concentration is a measure of its degree of civilization. As this happens, greed replaces fear as the basic human emotion, economic stuctures replace religious ones, and reason and rationality are valued over faith and artistic expression. But the rise of economic life calls forth economic competition, which ushers in the decline of the civilization; producers -- or, productive capitalists -- lose power to a new, more compact class -- the usurers, or finance capitalists. The productive elements of society (farmers, those occupied in crafts and manufacturing, and the merchant class) are caught in a bind: they are squeezed by those who control the money, on one side, and by competition from cheap labor (if in an empire, as people from the outer reaches of the empire migrate to the metropolis) or from trade (within the sphere of influence of the centralized civilization), on the other. At its climax stage, the civilization is highly concentrated, but its energy has been totally dissipated. Capital, ruled by greed, flees to the outposts of the civilization where returns are higher, and the society exists in a suspended state or disintegrates, until and unless it has contact with another, more energetic society -- "until supplied with fresh energetic material by the infusion of barbarian blood."[20]

In spite of the care with which Brooks avoided explicit reference to recent American politics, the historical parallels he drew between events in England in the early part of the nineteenth century and the decline of the Roman Empire were not lost on his late-nineteenth century American audience. In both of the earlier cases, the decline had been ushered in by a Panic, a sudden drop in prices, and a corresponding increase in the value of precious metals. The death of Augustus served to mark the moment in Rome, and the year 1810 in England; and

> from that day to this the slow contraction has continued, with only the break of little more than twenty years, when the gold of California and Australia came in an overwhelming flood; and, from that day to this, the same series of phenomena have succeeded one another, which eighteen hundred years ago marked the emasculation of Rome.[21]

When Brooks first discovered that "the same series of phenomena" seemed to characterize the rise and decline of different civilizations, he began to see his way through the chaos of the material he had collected; he also began to establish the continuity of that material with the events of his world in 1893. He had, in short, begun to appreciate the organizing power of a theory of history. The particular theory of history that he developed was grounded in the language and imagery of thermodynamics. If we can credit Brooks' account of its development, it emerged as an organizing scheme only after his researches were nearly complete:

> Finally, as the historical work neared an end, I perceived that the intellectual phenomena under examination fell into a series which seemed to correspond, somewhat closely, with the laws which are supposed to regulate the movements of the material universe.[22]

This is as close as Brooks comes to illuminating for us the process by which he came to see civilizations in terms of the ebb and flow of energy; and it is certainly not clear from this how the "series" he discerned in the essentially cyclical movement of civilizations through stages corresponded to any particular laws governing the movements of the material universe. The theory itself finds scant treatment in the body of the work. As Brooks wrote to his brother, during the revision of the manuscript he had sought to "cut out practically all the 'philosophy'".[23] Only in the Preface does Brooks devote much explicit attention to the theory of history the book is meant to support. There he makes clear that the volume takes as its subject of study the "dissipation of the energies" of civilizations -- which suggests that the analogy he discerned between historical series and physical law was between the decline of civilizations and the the process of entropic dissipation. (Nowhere, it should be noted, does Brooks use the term "entropy". But one need not use the term in order to be using the concept as a root metaphor; see the discussion of this point in note 17 to chapter two.) He is careful to present his theory tentatively, as hypothesis, rather than an iron law,[24] and this serves to reinforce the idea that he was serious in his attempt to advance his theory of history as a contribution to making of history a science.

Whatever science is to be found in the work has its origin in his use of terms borrowed from physics. Where others might find metaphor in ascribing to races or societies such qualities as energy, velocity, or mass, Brooks understood himself to be speaking literally, reaching toward science. "The theory proposed," he wrote,

> is based on the accepted scientific principle that the law of force and energy is of universal application in nature, and that animal life is one of the outlets through which solar energy is dissipated.[25]

Just fifty years earlier, this insight had been so far from being an "accepted scientific principle" that its promulgation and defense were taken as evidence of Julius Robert Meyer's madness. Brooks uses this insight as the starting point for constructing a theoretical perspective that is a delicate tapestry of thermodynamic insight and thermodynamic metaphor taken literally:

> Starting from this fundamental proposition, the first deduction is, that, as human societies are forms of animal life, these societies must differ among themselves in energy, in proportion as nature has endowed them, more or less abundantly, with energetic material....[26]

Part of this is technically, thermodynamically, correct, if "energetic material" means "low entropy"; societies do differ according to their "endowments" of scarce stocks of low entropy (fossil fuels, high grade ore deposits, etc.) and according to their ability to garner and to store low-entropy flows (primarily through agriculture, but also through direct solar gain, wind and water power, etc.). But Brooks' linking of this characteristic to the fact that societies are forms of animal life is his first step away from a strictly thermodynamic construction, his first step toward metaphor taken literally, and therefore his first step toward expanding the realm of signification of thermodynamic terms beyond the arena of science and into the larger pattern of rhetoric and thought that characterizes root metaphor. That is because the fact that human societies are forms of animal life has nothing to do with the fact that they make use of stocks of solar energy, and do so at different rates; other animals dissipate solar energy in their activities, but do not make systematic use of stocks of low entropy.

Brooks' work applies the language of thermodynamics in ways that defy verification of the content of terms. It is difficult to imagine what the referent of the term "energy" could be, for instance, in the statement "societies must differ among themselves in energy." One possibility is that Brooks means here the sheer number of calories expended from all sources in a society -- which, except for the glaring omission of some measure of the efficiency with which they are expended, could provide a rough measure of the ability of the society to influence other societies and the physical environment, both natural and artificial, within which the society's members move. Per capita caloric use could provide a quantitative, albeit rough, overall measure of what we might call the level of development of the society. Such a measure is not without its problems[27] -- but it is clear that this is not the sort of precision that Brooks intends. He is interested in translating vague concepts about various qualities and characteristics of societies into the language of thermodynamics:

> Probably the velocity of the social movement is proportional to its energy and mass, and its centralisation is proportionate to its velocity....[28]

None of the key terms here -- "social movement", "[social] energy," "[social] mass," "velocity," "human movement" -- have clear definitions in his work. One could, I suppose, develop a measure of the "power" or "strength" (there seems to be no non-metaphoric language for this concept) of a social movement by taking the number of people who belong to it (its "mass") and multiplying by the average number of calories expended per person in the activities, physical and mental, they direct toward the goals of the movement. A small number of people devoting all of their waking lives to the pursuit of some particular end would thus have the same "strength" as a larger number of people devoting a lesser share of their physical and mental energies to some end. But this, really, is an instance of the fallacy of misplaced concreteness: while mental processes do burn calories, there is no way of measuring how many, or of establishing an intersubjective comparison of the quality of thought produced by the burning of specified number of calories. The "power" of an idea cannot be measured by the calories it took to produce it, or by the calories' worth of mental of physical activity it prompts among those who understand and believe it. Nor can Brooks' notion of the "energy" of a race have any verifiable content; within his work, an assertion in need of demonstration -- that a civilization declines when its race runs out of energy -- is instead tautologous, for the only way to know whether or not a race has run out of energy is by whether or not its civilization has declined. Because Brooks was talking about forms of "energy" or "power" that cannot be denominated in calories when he talked about the power of an idea or the energy of a social movement, he was talking the language of entropy, not as thermodynamic law, but as metaphor. And because at some basic level the vision he propounded rested upon tautologies and circular logic, it is fair to judge it to be a world view much like any other in that one can elect into it by accepting its logical circles as self-evident axioms.

Was Brooks, then, employing entropy as a root metaphor? It is clear that he was seduced by the explanatory and data-ordering power of the abstractions that could be created by borrowing from the language of thermodynamics. But this seduction is not, by itself, sufficient to judge his use of thermodynamic ideas as an instance of root metaphor. The possibility exists that he was, as he expressed it to Henry, "quite mad" and that his work was "the dream of a maniac."[29] That is, had Brooks' world-ordering vision founded upon thermodynamic imagery been idiosyncratic, we could not count it as an instance of root metaphor, because as patterns of imagery in the thought and rhetoric of a culture, root metaphors are social phenomena.[30]

But, as was indicated at the beginning of this chapter, Brooks was not alone in turning to thermodynamics as a fundamental, world-ordering science; the late nineteenth century saw a flourishing of "philosophies" founded upon the relatively new science of thermodynamics.[31] Prominent among these "thermodynamic philosopers" was Wilhelm Ostwald, who had been smitten by a vision of energy as the primordial fact[32] (a perspective for which physics itself would eventually provide some justification). Ostwald began outlining his philosophy of "Energism" during his inaugural lecture at Liepzig in 1887, and in the following decades (up until his disillusionment with the ideal of an internationalist scientific culture in World War I) he elaborated it into a social and political vision. The imprint of the second law is unmistakable in the moral and ethical philosophy he developed as part of his Energism: free energy was the _summum bonum,_[33] "Waste no energy" the categorical imperative[34] -- an injunction that would be deprived of its force in a world not subject to the law of entropy.[35]

It seems clear from the example of Ostwald and the others who could be mentioned with him -- thinkers such as Henri Bergson, William James, Ernst Haeckel, Herbert Spencer, or those mentioned in notes 4, 5, and 6 to this chapter -- that Brooks was not alone in turning to energy imagery in an effort to find order and coherence in the world. Brooks' use of thermodynamic imagery thus helped to create and extend a larger pattern of such imagery in the rhetoric and thought of the culture of his day; that is, his use of energy imagery is an instance of the thermodynamic root metaphor.

It would be premature to jump from this conclusion to a full-scale evaluation of the entropy metaphor as it appears in Brooks' work, because Brooks was by no means an epic philosopher (he sought only to illuminate a dynamic he discerned in history) and because as cultural pattern, a root metaphor is larger than any particular instance of itself. Even so, it is possible to come to some sense of the merit and worth of Brooks' work as an instance of the metaphor.

Brooks' seduction by thermodynamic imagery did not prevent him from arriving at some insights that are not marred by the fallacy of misplaced concreteness. He notes that "whenever a race is so richly endowed with energetic material that it does not expend all its energy in the daily struggle for life, the surplus may be stored in the shape of wealth,"[36] an insight that anticipates the perspective articulated, to general ridicule, by Frederick Soddy a generation later (and discussed more fully in chapter six). He was led by this insight to focus on the interplay between the history of money, on the one side (specifically, its expansion and contraction through coinage and credit policies) and, on the other side, stages in economic development, patterns of land ownership, foreign policies of trading nations, and commercial and political history in general in his attempt to render explicable the rise and fall of civilisations. It was an approach that was, in its time, undersubscribed. It produced a distinctive narrative ordering of the material he covered; while it shares with Marxist history a grounding in material conditions of economic life and a concern for the antagonism between classes (here identified as debtor and creditor), it is definitely not Marxist in method or conclusion. The Law is unique among historical works that aspire to present theories with universal application in that the minutiae it renders explicable -- the details that occupy the center of its vision and justify its thesis -- have to do with coinage policies, bullion shipments, variations in the size of the money supply, and the political circumstances that shaped the policies that concerned these things.

Much of the value of Brooks' Law, as well as its flaws and excesses, stem from its character as the first, even partially-realized attempt to use thermodynamics as a fundamental, world-ordering science.[37] Charles Beard credits Brooks Adams with having raised one of the first thoughtful, substantial challenges to the nineteenth century's belief in progress,[38] and that challenge is traceable directly to his effort to discern in the declines of civilizations an order and regularity that he described as a "dissipation" of energy. His novel perception -- that patterns of energy use matter in history -- might have served as the foundation of a materialist interpretation of history to rival Marx's had he not been quite so smitten with the language and imagery of thermodynamics. Viewed solely as an attempt to demonstrate a theory of history, and unlike the work of his brother Henry, Brooks' work suffers because he could neither resist the esemplastic attraction of the concepts, language, and categories of thermodynamics, nor, once drawn to seeing the world through that set of lenses, historicise (or otherwise arrive at an understanding of the limits of) the understanding so achieved. Henry chose ironic distance and the vehicle of satire, creating for himself the role of secretive trickster. Had Brooks -- who seems by nature to have been less capable of such detachment, such dissimulation -- stayed firmly on materialist ground and reigned in his tendency to ascribe concrete qualities to abstractions, he might have begun articulating the ecologist's brief against Marxism.[39] But instead, Brooks wandered, elevating the concept of energy into a category that transcended measurement or indeed any need of being measured -- and this transgression proved fatal to his attempt to be remembered as a major theoretician of history.

As for the character of the root metaphor itself, we can note that in Brooks' work the entropy metaphor showed itself to be capable of supporting researches with a remarkable degree of precision, of a sort, and in particular areas. Money, as embodied energy, is the explanatory key. Thus, Brooks' explanation of the development of the steam engine:

> The least part of Watt's labor lay in conceiving his idea; he consumed his life in marketing it. Before the influx of Indian treasure, and the expansion of credit which followed, no force sufficient for this purpose existed; and had Watt lived fifty years earlier, he and his invention must have perished together.[40]

And his explanation of agricultural development:

> Arthur Young remarked in 1770, that within ten years there had been 'more experiments, more discoveries, and more general good sense displayed in the walk of agriculture than in an hundred preceding ones'; and the reason why such a movement should have occurred seems obvious. After 1760 a complex system of credit sprang up, based on a metallic treasure, and those who could borrow had the means at their disposal of importing cattle, and of improving tillage, as well as of organising factories.... The effect was to cause rapid centralization...[which] certainly raised the value of the land, but it also made the position of the yeomanry untenable.... Many... migrated to the towns, where the stronger...accumulated wealth in industry, the weaker sinking into factory hands.[41]

What is remarkable about these passages is that in neither case is technological development offered as explanatory cause; in both, the focus is on money, on the development of capital, as the enabling factor. We might, after Aristotle, say that for Brooks centralization was the final cause of such development, and money the efficient cause.

In spite of his willingness to relegate technology, the material cause of development, to the status of a derived influence, Brooks' Law can fairly be characterized as a materialist interpretation of history. The materialist foundation of his theory led Brooks to cut through the rhetoric surrounding European imperial expansion and to expose its economic -- or, more specifically, its financial -- root. The most valuable product of empire was the increased money supply that the imperial nation could enjoy; and on this view, the British experience in India was eminently sensible:

> Possibly since the world began, no investment has ever yielded the profit reaped from the Indian plunder, because for nearly fifty years Great Britain stood without a competitor.[42]

The focus on money as embodied energy could unite with geopolitical considerations to explain international relations and differences in rates of political development, as well:

> Germany lacked capital. Hemmed in by enemies, without a seacoast, she had been at a disadvantage in predatory warfare; accordingly she did not accumulate money, and failed to consolidate until, in 1870, she extorted a treasure from France.[43]

Brooks Adams' Law is at its most precise when it is explaining the details of economic history. In the facts and figures on exchange rates and money supply we are, once armed with the perspective of the metaphor, prepared to discover the causes of the rise and fall of economies -- and by extension, of cultures and civilizations. The perspective it offers gives us the chance to see connections between circumstances not generally seen as being related within other approaches to history; the British Empire in India contributed to the successful development of the steam engine, Waterloo represented the final victory of the banking class over the martial spirit,[44] and in the England of the Reformation, the incidence of the execution of witches -- a rough measure of the development of economic structures, which subverted religious ones, and which therefore called forth religious reaction -- is related to figures on trade and manufacturing:

> ...out of 277 victims, 234 came from the district to the east of a line drawn from Boston to Portsmouth. West of this line Oxford had most burnings; but, by the reign of Mary, manufactures had spread so far inland that the industries of Oxfordshire were only surpassed by those of Middlesex....[Only] two executions are recorded in the six agricultural counties north of the Humber -- counties which were the poorest and farthest removed from the lines of trade.[45]

Brooks Adams' Law, cleansed of all "philosophy," contains a stultifying amount of such detail. And yet, precise though such details may be, they are not what Pepper means when he talks about the precision of the world theories that are generated from root metaphors. Brooks' Law exhibits a precision of explanation, not of structural corroboration. His focus on monetary relations provides a narrative thread upon which a great deal of history may be strung; but it offers no absolute predictive detail. We are told that the rise of the class of usurers will usher in the decline of a civilization -- but we are not told exactly how that class will exercise its power, we are not told the specific means and forms through which they will contract the money supply. Nor are we given any exact measure of the decline of a civilization, beyond the general insight that a culture on the wane exhibits a "loss of vitality" in the arts, and a concomitant loss of power and prestige in world affairs. Behind Brooks' work is a glimmer of the attempt to found a science of economic history on the thermodynamic truth that the source of economic value is low entropy -- although Brooks himself never quite stated it so clearly. Perhaps because of that lack of clarity, he went on to attempt to articulate the connections between economic history, on the one side, and political, social, and cultural history, on the other, in the same thermodynamic language that provided such clarity into economic relations. But in this last effort, the language of thermodynamics led him away from science and toward the vague, non-quantifiable categories of racial, political, and cultural energy.

In Brooks' Law, then, the entropy metaphor shows us its capacity for precision in economic affairs, and its inability to reach with precision the other aspects of human social life that are built upon that economic foundation. In Ostwald's use of thermodynamic categories, we find the first example of the metaphor being put to the broadest of possible uses. While a root metaphor is larger than any particular instance of itself (which means that in applying the criteria of scope and adequacy we cannot limit ourselves to the work of a single author), Ostwald's use of the perspective suggested by the thermodynamic metaphor encourages the tentative finding that the entropy metaphor is not inferior to others in respect to its possible scope. And, finally, in the contrast between the tenor of Brooks Adams' Law and that of

Wilhelm Ostwald's Energism we find a difference of perspective that to this day characterizes visions founded upon the idea of entropy; to some, the second law of thermodynamics encourages grand dreams of efficiency and harmony with natural law, to others the law of entropy supports only the most pessimistic of outlooks. Henry Adams, whose use of the idea of entropy is the subject of the next chapter, was most assuredly in the latter camp.

Chapter Five

HISTORY AND DECLINE:
HENRY ADAMS AND THE IDEA OF ENTROPY

Both Brooks and Henry Adams made use of thermodynamic ideas in formulating their theories of history, and both came to pessimistic conclusions concerning the future of the American experience. Brooks foresaw nothing but centralization and eventual decline, until and unless America should be challenged by infusions of fresh, "barbarian" blood. Henry, too, saw centralization, and a world in which the American people became more and more the subjects of the industrial energies they had once thought to control.

The two brothers were not, of course, the first or only philosophers of history to raise a voice against the belief in inevitable progress. Nietzsche, Schopenhauer, de Tocqueville, Kierkegaard, Weber, Renan, Sorel, Inge, Spengler and Toynbee among social thinkers and historians questioned important components of the progressivist credo; and among poets and literateurs an important heritage reaching back to the Romantic movement and the works of Wordsworth and Blake, and including more recently the works of Eliot, Yeats, Joyce, and Pound, stands as an ongoing record of disillusionment with faith in the Western notion of progress.[1] Nor have they been unique in connecting this lapse in faith with the notion of entropy. Spengler called the idea of entropy the "definitive idea" of the nineteenth century, and Yeats' poem "The Second Coming" contains intimations of the second law ("Things fall apart; the center cannot hold"). But the Adamses were among the first to turn to the second law as a grand organizing idea for the entire flow of history, and Henry stands alone among serious historians in his attempt to project the "curve of degradation" of society by fixing a date, derived mathematically within a framework suggested by the second law, for the year that would "bring Thought to the limit of its possibilities."[2] Exactly what Adams meant to accomplish with his formula -- whether he did, in fact, believe in the possibility of a science of history, and whether he thought he had found its key in the second law -- is by no means simply answered, as we shall see.

Any attempt to discover what Adams meant to accomplish in his effort to make of history a science needs to take account of the fact that Henry Adams was a poseur, a man who, in his brother's estimation, "was never...quite frank with himself or with others," a man who "dearly loved paradox" and who was not above "propounding something which he knew would startle his guests or rouse in them the spirit of contradiction."[3] Henry's work can only be fully appreciated by seeing it, in its evolution, in relation to the broader picture we can get of him through an understanding of his life and character. This may seem a digression from the business of examining the idea of entropy and its use as root metaphor, but it is not; as often happens in the telling of the biography of an idea, it becomes necessary to look at the biography of an individual through whom the idea has been articulated. In order to show that Adams ultimately came to employ the idea of entropy in ways that are not quite what they seem at first glance to be, we need to examine carefully the genesis and development of his work. Our account will proceed along two lines: first, an inquiry into the nature and development of Adams' characteristic pessimism, and, second, an account of his attempt to wed that pessimism to a scientific foundation, particularly through his use of the second law.

One characteristic of the mind of Henry Adams was a profound ambivalence. That is, he was not indifferent, but was capable of seeing complexity and ambiguity in apparently simple subjects. As a young man of twenty four, writing to his brother Charles, he spoke of the temper of mind that made him unsuitable for public office:

> The more I see, the more I am convinced that [to] a man whose mind is balanced like mine, in such a way that what is evil never seems unmixed with good, and what is good always streaked with evil, an object seems never important enough to call out strong energies until they are exhausted, nor necessary enough not to allow of its failure being possible to retrieve; in short, a mind which is not strongly positive and absolute, cannot be steadily successful in action, which requires quietness and perseverance.[4]

For all this balance of mind, his pessimism was a consistent note struck throughout his life. There were, to be sure, occasional flashes of hope and optimism. A letter, written in 1877 as he began the researches for his major work in history, the nine-volume <u>History of the United States During the Administrations of Jefferson</u>

and Madison, records one such flash of optimism, which no doubt stemmed from his pleasure at having dedicated himself to the study of history.[5] There are other moments: his courtship of and marriage to Marian Hooper, and his early days as a reform journalist when he devoted himself to furthering the American experiment in democracy against the entrenched interests gaining influence in both parties. But his pessimism dominated. We find it as early as his Class Day Oration in 1858, when, at the age of twenty, he talked of the dangers of materialism and warned that neither science nor reason provided the hope of the world for the future. Four years later he was worried by the prospect of science becoming "the master of man," and spoke fatalistically of immanent social decline.[6] For Henry Adams, pessimism was a characteristic habit of mind -- one to which the events of his life would give ample reinforcement.

Adams spent the formative years of his young adulthood, from 1860 to 1868 (ages 22 to 30) as a private secretary to his father, Charles Francis Adams Sr., first in Washington while his father served as a congressman and then in London where his father, as ambassador to England, was charged with maintaining England's neutrality during the Civil War. The experience left him with a sense of the Machiavellian duplicity of politics, and brought to him the appreciation that his mental temper was such that he was not likely to succeed as a politician. While in London, and then for a time in Washington, he tried his hand at freelance journalism, seeking through that enterprise to conjoin his desire to shape events (the family calling, of sorts) to his reflective and literary cast of mind. In 1870 he took a professorship of history at Harvard where, as the junior member of a three-member department, he was responsible for covering the vast ground between classical and modern history.[7] He took the job under pressure from his family and from Harvard, but only when the added inducement of the editorship of the North American Review was included among his responsibilities; he was as yet unwilling to abandon his career as a reform journalist. But this career ended in disappointment during the election of 1876, when he saw the independent movement he had been instigating and supporting in the pages of the Review fragment between the two major parties and so lose any hope of affecting the outcome of the election.[8] He was, shortly afterward, brought to task by the publishers of the Review for the "political character" of the October 1876 issue; he used that occasion to precipitate a break and resigned his post.[9] His disaffection with politics was complete; it became obvious to him that the world as it was constituted had no room for him to pursue the calling that had been the Adams' for generations.[10] One semester later, he resigned his teaching post, and began his work on the biography of Albert Gallatin (which led, ultimately, to the monumental History), and his retreat from the world was final; henceforth, he would be a private man of letters, a gentleman scholar, accepting only those positions -- such as the presidency of the American Historical Association -- whose duties he could safely ignore.[11]

This episode may mark the beginning of Adams' sense of himself as a failure. Although he took to his new-found career as an historian with genuine enthusiasm, he never ceased to distrust politics and its effect on the moral character of its practitioners.[12] If, in his later years, his pose as a failure has an element of sham about it, there is this gleam of insight: politics had frustrated Adams by refusing to yield to him any sense of an internal order, any sense of being founded upon principles or laws. Some critics account for Adams' pessimism by suggesting that if Henry Adams had been frustrated, then all the vanity and self-righteousness that an Adams could muster -- and these, as family traits, were considerable -- required that the world, too, share some of that burden. In Jordy's work, for instance, we find this approach, which allows Jordy to present Adams' critique of the culture of the emerging industrial state as the product of so much sour grapes: Henry Adams, failed patrician, finds that a world that does not solicit his guidance or recognize its own need for his moral probity is seriously flawed.[13]

But Adams' pessimism was not the simple result of an act of projection, as this interpretation would have it. Adams' work and the intellect it reveals indicates that here was not a man ruled by autonomous drives and blindly subject to emotional responses consequent upon their frustration; rather, "his constant awareness of what he was about makes it evident that he was thoroughly in control."[14] If Henry Adams failed, so too did the world -- not out of a childish need for a compensatory defense on Adams' part, but because it remained inscrutable to his keenest powers of observation and insight.

It is not difficult to describe the death of Adams' wife, by her own hand, as an important influence on his life -- though it is difficult to describe with any exactness the effect that her suicide had upon his work. At the time of the death, in December 1885, Henry was in the middle of the writing of the History, and some critics account for an obvious change in tone and outlook in that work by reference to this tragedy.[15] It is clear that he was deeply affected: he spoke of his life having been "cut in two," and referred to the time left to him after his wife's death as his "posthumous existence." One measure of the pain this episode held for him is found in the fact that he skips over the entire period in his pseudo-autobiographical Education; the thirteen years of his married life and the seven years following his wife's suicide are omitted.[16] His only mention of his wife's death is obscure, placed as it is in this passage concerning the death of his sister, to whom he was very close:

> Flung suddenly in his face, with the harsh brutality of chance, the terror of the blow stayed by him thenceforth for life, until repetition made it more than the will could struggle with; more than he could call on himself to bear.[17]

Adams refers to his sister's death as the beginning of "the last lesson -- the sum and term of education," which is consistent with his avowal that his education ceased in 1871 -- the year of his marriage -- and that he then began to put it to practical uses. If the main movement of Adams' education was his "transition from the man of thought to the man of feeling," and if "The profoundest lessons are not the lessons of reason; they are the sudden strains that permanently warp the mind," then his education was by then complete; he knew the joy of being "absurdly in love" and had learned from Marian Hooper that -- as one critic put it -- "the riddle of life cannot be solved by the mind alone" -- and he knew also tragedy, from having watched his sister succumb, after "ten days of fiendish torture," to tetanus.[18] If life taught him to value emotion, instinct, and intuition more than cold reason and rationality, how much more painful the lesson when all around him, every day, society gave evidence of becoming increasingly rationalized, increasingly dependent on science, technology, and the suppression of the emotional side of human nature.

If personal tragedy and the frustrations of practical politics played a role in shaping Adams' native pessimism, there was also an important intellectual component: his encounter, during the crisis summer of 1893, with the ideas and theories of his brother Brooks. If we could have their many conversations from that summer reconstructed for us in exact detail, we might then know the nature of the impact of Brooks' manuscript on the cast of Henry's thought, and the degree to which Brooks helped Henry to achieve an articulation of his own pessimistic view of history.[19] In the absence of such knowledge, we can only make an informed guess.

It seems clear that Brooks did not introduce Henry to the sort of "perplexities" with which they both grappled. But it seems equally clear that Henry's encounter with his brother's <u>Law</u>

marked an important event in his life, one that set him on the path toward a clearer articulation of his own philosophy of history, and perhaps even brought to him an appreciation of the need for a philosophy of history at all. For the thrust of Henry's work changed; no longer merely the historian documenting eras and epochs, he sought to describe the movements between them. What had been background in the History would, in the work he did after 1893, become foreground: the problem of relations between points of fixity. And as Henry endeavored to work out the problems of a philosophy of history, he was drawn, ultimately, to use the language and imagery of thermodynamics that he had encountered in his brother's work.

Henry's next major work was the "Tendency of History," a long letter communicated to the American Historical Association in lieu of a presidential address, which (he told Brooks) he wrote as a sort of "introduction or preface" to his brother's work, to prepare the ground for its reception.[20] The work is liable to misinterpretation due to the ambiguity of the word "history" in its title and text: Adams is not concerned so much to discuss eschatology here as to describe the tendency of history as a discipline; nevertheless, he uses the occasion of discussing the prospects for a "science of history" to make some remarks about the general trend of events and the direction of the movements that history, as a discipline, records. He suggests that history (as a discipline) is struggling toward unity, toward the grand overarching generalization that might "reduce all history under a law as clear as the laws which govern the material world." Rare is the historian who has not felt him- or herself to be on the verge of discovering such a law, who has not seemed to have it "in his [sic] inkstand." Then, a few pages later, we run across a passage which is interesting not only for the way in which it foreshadows Brooks' major theme -- which was, after all, his intention for the work, at least as he communicated it to his brother -- but for what it seems to say about science as Adams understands it:

> Darwin led an intellectual revival much more hopeful than any movement that can now be seen in Europe, except among the socialists. Had history been converted into a science at that time it would perhaps have taken the form of cheerful optimism which gave to Darwin's conclusions the charm of a possible human perfectibility. ...If a science of history were established today on the lines of its recent development I greatly fear it would take its tone from the pessimism of Paris, Berlin, London and St. Petersburg....[21]

In addition to suggesting that the laws discovered by any science of history would be generally pessimistic in outlook, Adams has also suggested that science is a social enterprise, shaped less by the nature of its object -- truth, or knowledge -- than by the social forces that give rise to it. Since Adams employed the idea of entropy in an avowed attempt to make of history a "science," an understanding of what he might have meant by that term is crucial to an understanding of the reasons for his use of the idea of entropy.

We can begin to understand what Adams thought of science by tracing, through his later work (work produced after 1893), the comments he made on science and the ways in which he used scientific imagery in constructing his philosophy of history. His Education, his "Letter to American Teachers of History", and his "Rule of Phase Applied to History" are most relevant for our purposes, since in each of them he makes explicit use of the idea of entropy. But each of his major works from this period offers insight into to his effort to present a law of historical change in the language of science, and so it will be best to proceed sequentially in order to show the development of his thought. We begin with an examination of the development of his thoughts about history, as seen in his work up to and including the Education; then, we will focus more explicitly on the "scientific" historical theories of the "Rule" and the "Letter".

After completion of the "Tahiti" and the "Tendency" in 1893 (see note 20), Adams' next bit of writing was a short essay for the first volume of the American Historical Review. In no one's estimation of Adams' work would it count as a major piece; nevertheless, it deserves mention here, for Adams took the occasion of offering a minor correction concerning a relatively insignificant figure in his nine-volume History to reflect on the question of historical accuracy. "At no other time in his career did Adams so cogently attack the absolutism implicit in his documentation within the History," says one critic of the essay.[22] The "absolutism" of the History is found in the way Adams tried to let the documents speak for themselves, as if the historian's only function were to make primary source materials available to a wider audience. In the History he manipulated documents so that they flowed into one another with scarcely a hitch, leading the narrative -- and the reader -- toward conclusions which he scarcely suggested. "Only give a running commentary on the documents in order to explain their relation," he had written by way of advice to a novice historian.[23] Certainly he realized that there was an element of choice, and thus a chance for error, in the selection of documents; but once selected, the documents themselves served as fixed points and all that remained was for the historian to establish their relation, their context.[24] But now, in his correction, Adams allowed that history was not that simple and not that error-free. He started off the article with a listing of possible errors: there could be error in "personal...observation of facts," in the relations between facts, in the authorities cited, in "the facts themselves" if they led to an incorrect conclusion, and, finally, there was always "the reader's personal error." "The sum of such errors," he concluded, "must be considerable."[25] He then went on to amplify what he called a "rule" of historical error for a page and a half. If his comments reach no deeper than the elementary cautions on accuracy that are now commonplace in even the most basic history texts, they are nonetheless interesting for being the first intimation that Adams no longer believed in the possibility of an objective science of history. His realization of the possibility for error may have spurred his search for the grand law that would reveal the "tendency of history," for, as he put it later in his Education, "if history ever meant to correct the errors she made in detail, she must agree on a scale for the whole."[26] He is here suggesting a reversal of the method he employed in the History, and making it sound as if the historian's struggle for accuracy led him to philosophize about history. (The historian's task as he had understood it before was to discern the relationship between unequivocal facts; now he was convinced that the facts themselves would not speak -- at least, not sensibly -- until the relations between them had been described through a theory of history, a "scale for the whole."[27]) The more likely development in his thought was that Brooks' Law showed him the virtue of the grand organizing scheme, the attempt to find unity in the multiplicity of history, and that this realization in turn led him to see the limits of finding meaning in bare facts.

However he came to appreciate the need for a philosophy of history, Adams' next major work was his classic volume in medieval studies, Mont Saint Michel and Chartres, privately printed in 1904 (and commonly referred to as the Chartres). It may seem paradoxical that one who searched for a law of history that could describe the future turned his attention to the past and the Europe of the eleventh, twelfth, and thirteenth centuries, but it will not do here merely to assert that Adams was a thinker who loved paradox. The Chartres is best understood as a companion volume to the Education (the work he undertook after it), and the relationship between them can be seen in the descriptive subtitles he appended to them. As he described his plan for the two works in his Education:

> Any schoolboy could see that man as a force must be measured by motion, from a fixed point. Psychology helped here by suggesting a unit--the point of history when man held the highest idea of himself as a unit in a unified universe. Eight or ten years of study had led Adams to think he might use the century 1150-1250 expressed in Amiens Cathedral and the works of Thomas Aquinas, as the unit from which to measure motion down to his own time, without assuming anything as true or untrue, except relation. The movement might be studied at once in philosophy and mechanics. Setting himself the task, he began a volume which he mentally knew as "Mont-Saint-Michel and Chartres: A Study in Thirteenth Century Unity." From that point he proposed to fix a position for himself, which he could label: "The Education of Henry Adams: A Study in Twentieth Century Multiplicity." With the help of these two points of relation, he hoped to project his lines forward and backward indefinitely, subject to correction from anyone who should know better.[28]

Adams achieved a portrait of unity in the Thirteenth Century only by ignoring those elements -- politics and economics -- that would have confused the picture. But this in no way lessens the achievement of the volume. He was after the art of the era, the feeling, and not fact; he reported the legends of the time as they would have been told then, for instance, and not as modern historical scholarship might have corrected them, because "the poetry is history and the facts false." The book weaves together the two great themes, the Church Architectural and the Church Spiritual/ Intellectual, with great artistry; with a fine attention to detail and from an obvious knowledge of documentary and secondary literature, it nevertheless sustains a gentle voice of great intimacy. The volume was written, Adams said, for his "nieces and nieces-in-wishes," and it successfully maintains the device of presenting itself as a narration by a genial and remarkably learned uncle.

The chapters fall into three main groupings: the first three concern the cathedral at Mont-Saint-Michel and the Song of Roland, both of which are emblematic of a masculine-dominated, martial outlook. The long middle section -- nine chapters -- deals with the decline of masculine emphasis in the Church, the rise in importance of the Virgin Mary, the highest statement of her worship (the cathedral at Chartres), and her ultimate eclipse. The final three chapters repeat in fine the outline of the work as a whole, tracing the rise of Mariology and mysticism consequent on the crisis in the rationalist, masculine theology of the schools, the flowering of her power, and her ultimate decline with the return to rationalism prompted by Aquinas. As Adams relates it, then, the construction of the cathedral at Chartres, which celebrated the power of woman, coincided with a failure in scholastic philosophy (i.e., abstract masculine thought).[29] The early scholastics had "tried realism and found that it led to pantheism. They tried nominalism and found it ended in materialism. They attempted a compromise in conceptualism which begged the question. Then they lay down exhausted." In the impasse of the schools, Mary's influence reached its height; "In the bankruptcy of reason, she alone was real."[30] "This," says one of Adams' biographers, "was the moment that Adams admired most."[31] For a brief period -- sixty years, between 1140 and 1200 -- Europe stood precariously at the pinnacle of an "organic unity"; art and science were one, and the poetry, architecture, and theology of the period celebrated -- and were ennobled by -- the ascendancy of mysticism over reason, ecstasy over logic, and faith based in love over faith based in the intellect.[32]

With the Chartres Adams had formulated a point of fixity by which relation, and change, could be measured. From there, his task was twofold: it remained for him to articulate his point of reference in the modern world, a point grounded in the chaos of multiplicity, and then to erect a doctrine of relation to connect the two. The first he accomplished in his Education, and the second he undertook in two articles: his "Rule of Phase Applied to History" in 1909 and "A Letter to American Teachers of History" in 1910.

In the Chartres, Adams had written that "the attempt to bridge the chasm between multiplicity and unity is the oldest problem of philosophy, religion, and science, but the flimsiest bridge of all is the human concept, unless somewhere, within or beyond it, an energy not individual is hidden; and in that case the old question instantly reappears: What is that energy?"[33] In the twelfth century, Adams believed, that energy had been the Virgin, and her power over the imagination, her power as a symbol of the eternal human desire for inner and outer harmony could be seen in stone and glass and in the miracles ascribed to her. But the twentieth century presented no such easy answer; the world seemed ruled by a confusion of forces. For a time, Adams became interested in figures on coal production as indicative of the vast energies of the age.[34] But coal, ultimately, was not the thing he sought; he needed a symbol, an emblem of the age as convenient and as telling as the Virgin was for the twelfth century. "Images are not arguments, rarely lead even to proof," he knew, "but the mind craves them."[35] At the Paris exposition of 1900, he found an excellent symbol to contrast with the virgin: the dynamo. It became a symbol of infinity for him, of a hideously anonymous power that was brute, silent, and dehumanizing:

> As he grew accustomed to the great gallery of machines, he began to feel the forty-foot dynamos as a moral force, much as the early Christians felt the Cross. The planet itself seemed less impressive, in its old fashioned, deliberate, annual or daily revolution, than this huge wheel, revolving within arm's length at some vertiginous speed, and barely murmuring--scarcely humming an audible warning to stand a hair's breadth further for respect of power.... Before the end, one began to pray to it; inherited instinct taught the natural expression of man before silent and infinite force. Among the thousands of symbols of ultimate energy, the dynamo was not so human as some, but it was the most expressive.[36]

The passages in which Adams discusses the dynamo, making of it a symbol for the forces of the modern age, contain some of his sharpest statements about the nature of the decline he saw in society; we can also find in them the first suggestion that the law of entropy is the governing principle behind that decline. In accordance with his brother's law of centralization and decay, Adams points out that modern mechanical powers--"steam, electric, furnace, or other"--"have to be controlled by a score or two of individuals who have shown capacity to manage [them]." But these individuals are not aware of their context--they are ignorant of the parts they play, the forces that move them, their relation to others: "Most of them have nothing to tell, but are forces as dumb as their dynamos, absorbed in the development or economy of power." So it is that "Modern politics is, at bottom, a struggle not of men but of forces. The men become every year more and more creatures of force, massed about central power-houses."[37] Adams saw, then, a technological imperative destroying human individuality, creating a world in which -- paradoxically -- humans had less and less control over the direction of history just as they seemed to be gaining greater and greater control over energies that let them accomplish their will in nature. Little could these forces produce unity; they were anarchic, productive of chaos, plunging the world into multiplicity even as they centralized social and economic life. Trying to imagine the world as a child born in 1900 would experience it,

> He found himself in a land where no one had ever penetrated before; where order was an accidental relation obnoxious to nature; artificial compulsion imposed on motion; against which every free energy of the univese revolted; and which, being merely occasional, resolved itself back into anarchy at last.[38]

Far from the organic unity of the middle ages, humans now understood themselves to be in a universe (or multiverse) whose underlying principle was chaos, rather than order. This was the lesson taught by the kinetic theory of gases, derived in accordance with the second law; all matter is in motion, a random agitation, the molecules colliding with each other "seventeen million times a second, much like an automobile in Paris."[39] This perspective, as well as the powerful forces unleashed in steam and electricity, was unprecedented in human history.

Adams went on to elaborate the this new outlook, taking the second law to be "the law of the new multiverse":

> He could not deny that the law of the new multiverse explained much that had been most obscure, especially the persistently fiendish treatment of man by man; the perpetual effort of society to establish law, and the perpetual revolt of society against the law it had established; the perpetual building up of authority by force, and the perpetual appeal to force to overthrow it; the perpetual symbolism of a higher law, and the perpetual relapse to a lower one; the perpetual victory of the principles of freedom, and their perpetual conversion into principles of power; but the staggering problem was the outlook ahead into the despotism of artificial order which nature abhorred. The physicists had a phrase for it, unintelligible to the vulgar: 'All that we win is a battle--lost in advance--with the irreversible phenomena in the background of nature.'[40]

Here, then, is the outlook provided by the second law of thermodynamics, reaching all the way from the heights of ontology -- the very structure of existence in "supersensual" realms -- down to the commonplaces of political life and the unavoidable tension between ideals and practices. "Chaos was the law of nature, Order the dream of man," as Adams summarized it in plain words, and under the second law humans were fated to see that dream slip ever from their grasp.[41]

Adams thus found the second law to be a powerful explanatory device -- a vivid metaphor -- through which to articulate his pessimistic vision of the future of an industrial, technological society. At first glance, his work seems to be similar to Brooks' in its approach to and use of the laws of thermodynamics: both ascribe "energy" or "power" to ideas, social movements, and cultures, and in both we find that these forces are subject to the law of entropy. And yet there is a major difference of style and tone in the work of the two brothers. Brooks, one senses, is working with the idea of entropy sincerely, in the image of historian-as-scientist; Henry, it seems, has a bit more business than that to accomplish; he is working with the idea of entropy in the image of historian-as-poet.

We are on difficult ground here, for great importance attaches to a difference that is difficult to describe; it is, ultimately, not a difference in content but a difference in style. Because it is a cardinal point about root metaphors that they be taken literally -- or at the least, not be appreciated as "greater or lesser poetry" (see chapter two, p. 45) but as good-faith attempts to model, in exact proportion and detail, the phenomena under consideration -- this difference in style becomes a deciding factor in whether or not one can say of Henry Adams that he, like his brother Brooks, was a partisan of the idea of entropy as root metaphor. It seems we face the difficult task of proving or disproving the rather nebulous thesis that one wrote as scientist, the other as poet. But for Henry as well as Brooks, the law of entropy as it applied to history had to do with whether or not history was to be a science. This means that we have the opportunity to approach the question obliquely: instead of attempting to discover whether or not Henry's mind is the mind of a poet, we can turn instead to the relatively easier question: what did Henry Adams think of science? The answer we give to that question will show us the nature of his relationship to the idea of entropy, and allow us to decide whether or not he, like Brooks, is to be counted among the partisans of the idea as root metaphor.

We can get a sense of Henry's attitude toward science by following the development of his own "scientific" philosophy of history. Adams presents the first outlines of his theory of history in the Education, in the last six chapters but one (i.e., chapters 29 though 34, excluding chapter 35). Chapters 33 and 34 are especially important; in them he sets out "A Dynamic Theory of History" and "A Law of Acceleration". The first of these owes an obvious debt to his brother Brooks' Law, for it traces through human history the development and economy of force or energy (Adams did not distinguish the two concepts) through successive stages of civilization. In the succeeding chapter, he argues that the pace of development is increasing geometrically and makes his first attempt to fix, according to mathematical law, the phases of history. The coal output of the world had doubled every ten years between the years 1840 and 1900 (in terms of utilized power, given advances in economy of use of force); this suggested to Adams a mathematical formula that might be extended backwards indefinitely. But figures for coal are not especially relevant to ages in which coal was unimportant, and the forces of other eras -- political forces, religious forces, intellectual forces -- are not so easily measured. Given that, "Theory may assume what it likes -- say a fifty or even a five-and-twenty year period of reduplication for the eighteenth century, for the period matters little until the acceleration itself is admitted." The period does matter, however, if the theory is to be in any sense scientific; and if this cavalier dismissal of the all important time-scheme is not enough to indicate to his readers that he is less interested in quantifiable science than in offering an untestable myth about the direction and characteristics of history, he goes on to say that "one might, for convenience, use the formula of squares to serve for a law of mind." Notwithstanding Adams' sardonic assertion (a dig at pragmatism, most likely) that "convenience was truth," his use of the law of squares -- the principle behind a standard geometrical progression, where successive terms are derived by squaring the previous term -- was purely arbitrary.[42] Admittedly, his avowed purpose was to introduce the notion of an increasing rate, and not to fix it with any exactness. But when, in his "Rule of Phase Applied to History", he attempted to fix that rate exactly, his precision was achieved only at the cost of an even greater arbitrariness.

The title of the "Rule" leads us to expect that it applies Gibbs' rule of phase to history. Briefly, the rule of phase describes the relationship between temperature, pressure, and volume of a substance and the number of "phases" of that substance that can co-exist at equilibrium. For water, for instance, the three commonest phases are water, ice, and vapor, and the three can co-exist at equilibrium only at a single point in temperature, pressure, and volume -- the so-called "triple point". This result is given by Gibbs' simple formula: F=C+2-P, where F represents the number of degrees of freedom, C the number of components, and P the number of phases in the system. For the example of the triple point, the component -- water -- is unity, and the number of phases is three, so there are no degrees of freedom: none of the values for the variables are open to fluctuation, if all three phases are to co-exist. If only two phases are to co-exist, then one degree of freedom is obtained: a constant volume of ice and water can co-exist across a broad range of temperature, if the pressure is adjusted accordingly.[43] At least one critic has noticed that Adams' theory bears little relation to Gibbs' rule: "Apply the formula to history. Of how many components does history consist? Wisely, Adams does not say. Phases? To be sure, he offers seven; but is he interested in the conditions of acceleration and attraction (his replacements for temperature and pressure) under which, say, the religious, electrical, and ethereal stages would coexist? To ask the question is to reveal the absurdity."[44]

To state Adams' theory is to reveal the absurdity of supposing it to be "scientific" as that term is commonly understood. He describes several distinct phases in history: the religious phase, which gave way to the mechanical phase, the electrical phase (which was inaugurated in 1900 with the advent of the dynamo), and a phase yet to come -- the ethereal phase, in which society would think "in terms of Ether or the higher mathematics," or "pure mathematics and metaphysics."[45] Whatever "science" or convenience there might be in these phases as genuinely descriptive devices is undercut by Adams' whimsy: once again, he arbitrarily selects the law of squares as the principle governing acceleration from one phase to the next, and then attempts to affix dates to the phases. If the renaissance is dated as having begun in 1600, then the mechanical phase that it brought about lasted 300 years; the religious phase, then, would have lasted for 90,000 years -- 300, squared -- and "the next or Electric Phase would have a life equal to /300, or about seventeen years and a half, when -- that is, in 1917 -- it would pass into another or Ethereal Phase, which...would last only /17.5, or about four years, and bring Thought to the limit of its possibilities in the year 1921."[46] Adams allows that there is uncertainty in the dating scheme -- *not*, however, because his use of the law of squares is arbitrary, but because there is uncertainty as to the beginning of the Renaissance--the start of the mechanical phase. Even if the life of the mechanical phase were pushed back a hundred years, he says, "the difference to the last term of the series would be negligible. In that case, the Ethereal phase would last till about 2025."[47]

Those of us who are living through the period about which Adams presumed to predict might not find the difference between 1917 and 2025 "negligible." Even if, in the grand scheme of history, the range of a century actually can be seen as insignificant, there are other, more serious problems with Adams' theory that prevent it from being scientific. As one scientist to whom

Adams showed a draft of the Rule pointed out, the selection of units for time is essentially arbitrary, and the time scheme would be changed drastically by taking centuries, rather than years, as the basic unit.[48] The theory is non-falsifiable, given the ambiguity about what "Thought at the limits of its possibilities" may or may not be. And Adams' reference to Gibbs' work is tenuous and inappropriate; what was novel in Gibbs' theory was the description of the coexistance of phases at equilibrium, and that notion finds no parallel in Adams' discussion of phases in history. Such criticisms -- and the others that could be levelled against the Rule -- come so easily that one should begin to suspect that they are missing the point. If the Rule seems to owe no more to Gibbs than the use of the single word, "phase," there is still something else that Adams gained by couching his theory in the language of a law of science derived from the second law of thermodynamics: the rule of phase brings to Adams' theory of history what one critic calls "the abracadabra of authoritarianism."[49]

Adams employed a similar appeal to the authority of science in his Letter, written the year after the Rule. He ransacked various disciplines in order to offer "scientific" proof that history invariably recorded decline, wherever one looked: geology, anthropology, psychology, economics, paleontology, biology. As Adams presents it, if history is to become a science, it must choose from among three general organizing schemes, each derived from science: the principle of evolution, and the first and second laws of thermodynamics, which he represented in a graph with three lines, one tending upwards, one downwards, and one horizontal. (Conspicuously absent, of course, is any _cyclical_ notion of history.) Historians, he says, have been attached to the principle of evolution and the notion of progress that it suggests largely for reasons of "sentiment;" Adams marshalls his carefully selected evidence in support of the dubious argument that historians ought to discard that sentimental attachment and make their choice based on faith in the perceptions of scientists, who have (he purportedly demonstrates) unanimously taken the second law as the principle that explains history. No matter that the principle of evolution and the first and second laws are not truly in contradiction, as Adams presents it, for the problem -- the tendency of history -- is real. But why should Adams have couched the argument in such a dubious form, and supported it with "evidence" so obviously one-sided and incomplete?

The "scientific" theory of history that emerges from these articles and chapters is so obviously flawed that Adams' reputation as a thinker must suffer if we take seriously the notion that he was trying to make of history a science. It is much easier to take him at his word, when he says of the _Letter_ (and perhaps, by extension, of the _Rule_, also) that it is his "little joke:" "the fun of it is that not one of them [the teachers of history to whom he sent the privately printed _Letter_] will understand the fun.... I don't know that I should see the joke myself if I were not its author."[50] The joke -- and the levels of irony within it -- are obscured by critics who applaud his "call for a science of history" but then chastise him for his failure to achieve it, by critics who sympathetically make allowances for the intelligent layman lost in a confusion of science, or by critics who hope to salvage Adams' science by an appeal to the "pragmatic test."[51] (Adams does seem in retrospect to have been uncannily prescient about some affairs, but it is doubtful that his "Ethereal Phase" had much of anything to do with either World War I or Einstein's General Theory of Relativity, as one critic suggests; still further was he from predicting the atomic bomb, as yet another seems to believe.[52])

To be sure, Adams wrote that "A science cannot be played with;" yet it seems this is exactly what he did. In his Tendency he notes that his colleagues will likely reject any "hypothetical science that must obviously be incapable of proof," and by those lights they should certainly have rejected Adams' theory as he came to elaborate it. Lest his audience for the Tendency miss the point Adams had been trying to make about the essentially historicist character of science, he went on to add: "We should take the same attitude [toward such a science] as our fathers took toward the theories and hypotheses of Darwin." As Adams saw it, the theory of evolution was not so much a scientific truth defendable with evidence, as a perspective that is beyond proof, a perspective that is a matter of faith. He identified the cause of rationality and reason -- the cause of science -- with the forces of religious reaction, finding in those who rejected the Darwinian faith the more proper "scientific" attitude.[53]

Given the perception of science that is at the core of the Tendency -- and at the heart of his later works -- it is difficult to see how anyone could read this address as a straightforward call for a science of history.[54] Adams, who exhibited none of the scruples concerning "normative" language that modern day social scientists have developed, never directly says that historians should adopt the principles and the outlook that would make of their disicpline a science. A reader sensitive to nuance of language, and cognizant of Adams' efforts to rediscover in his own life the elements of intuition, artistry, and sense of mystery that the modern world abjured, might even detect a note of resigned wistfulness in the Tendency: "No one who has watched the course of history during the last generation can have felt doubt of its tendency. Those of us who read...the Origin of Species and felt the violent impulse which Darwin gave to the study of natural laws, never doubted that historians would follow until they had exhausted every possible hypothesis to create a science of history." Or, "That the effort to make history a science may fail is possible, and perhaps probable; but that it should cease, unless for reasons that would cause all science to cease, is not within the range of experience." Note that Adams does not judge the value of the attempt; he merely states the situation as it is, paradoxically presenting it as an insight gleaned from experience. And, in a particularly double-edged phrasing, he adds: "Science itself would admit its own failure if it admitted that man, the most important of all its subjects, could not be brought within its range."[55]

Adams' goal in his theory of history was to blend science and artistry in order to portray the value of the one at the expense of the other. He sought to communicate the failure of the scientific era in a language that would be easily understood, in a rhetoric that at once explained the failure and gave, to those capable of seeing it, a prime example of that failure. The obvious message was there for those who took their science seriously, as authority: society is in decline. That message was all the more forcefully represented to those who were aware of -- or capable of reading his implications about -- the essential historicity of science, its arbitrariness as a way of interpreting the world.[56]

Adams has been criticized for railing against what he, at other times, held to be inevitable and so resigned himself to -- the suggestion being that either he was taking on a "straw man" in his ranting against modernity or that there was a paradoxical distance between his thought and his action. Here, in his theory of history, we see the paradox most sharply portrayed. He foresaw the "tendency of history," bemoaned it, yet did what he could to further it. If history was to become a science, he would help it to be so, all the while giving every indication that he thought science an enterprise far inferior to art, rational thought a crippling affliction in the absence of its complement, intuition, and the confusing, soul-deadening multiplicity brought about by science in the modern world an inferior state of affairs to the organic unity he discovered in the middle ages as he reconstructed them.

Little, then, could the law of entropy have taken on for Adams the status of an unchallengable truth descriptive of a broad range of phenomena. The second law was the paradoxical product and prophet of science as an agent of decline. Its lack of importance for him can be seen in the variety of scientific imagery he used before settling into the second law: he compared thought to a meteor, rounding the sun and acheiving its perihelion in 1917; or, it was a frozen glacier, melting and running its course to the dead level sea, whence it could never rise again; or, it was a dynamo, throbbing with uncontrollable, unlimitable, inscrutable potential power.[57] That he came, ultimately, to the second law as the best symbol for the perception he wanted to communicate should be no surprise; it, like the rays of radium newly discovered in the late 1800's, must have seemed "positively parricidal" in the relationship it bore to science, its parent. And unlike the geological or astronomical images, the law of entropy was a grand law of cosmic import that foreclosed any possibility of rebirth or renewal. History, he knew, was irreversible; he was not likely ever to see the resurrection of the glorious unity of the Middle Ages in his time, and he he did not need the second law to teach him that.

Henry Adams often referred to himself as a "Conservative Christian Anarchist," a phrase calculated, no doubt, to startle, given its conjunction of apparently contradictory beliefs. But there is a reasonableness to the phrase, a logic that provides insight into the nature of Henry Adams' beliefs. The Christian part of his belief lay in his nostalgia for the Middle Ages, the era when society and culture and polity achieved a unity in the worship of the Virgin. His conservatism is evidenced in the dissenting voice he raised against the notion of progress, and in his unwillingness to accept as desirable the revolutionary changes brought by industrialization and technological development. He was an anarchist in exact proportion to the degree he was a determinist. Believing that "in the social disequilibrium between capital and labor, the logical outcome was not collectivism, but anarchism,"[58] Henry was, more often than not, ready to accept what he thought to be inevitable. In calling himself an anarchist, he was looking ahead, beyond the next discernable phase of political organization, which was, to his mind, a centrally-organized system of technocratic state socialism. "If you feel obliged to take part [in the next presidential campaign]," he wrote to Brooks in 1898,

> you must lift off from silver, and lift into Socialism. Not that I love Socialism any better than I do Capitalism, or any other Ism, but I know only one law of political or historical morality, and that is that the form of society which survives is always in the Right; and therefore a statesman is obliged to follow it, unless he leads. Progress is Economy! Socialism is merely a new application of Economy, which must go on until Competition puts an end to further Economies, or the whole world becomes one Socialistic Society and rots out. One need not love Socialism in order to point out the logical necessity for Society to march that way; and the wisdom of doing it intelligently if it is to do it at all.[59]

Beneath this glib presentation lies a considered fatalism. And the logic that applies to the acceptance of socialism applies as well to the phase that must succeed it, the phase in which the centrally-organized society begins to fragment and to fall apart from a hollowness at its core. The inevitibility of this phase, which Henry understood to be "anarchism", he thought to be amply demonstrated by historical experience, even if history could never, as Brooks thought, be truly made into a science.

To Henry's mind, science itself ultimately contributed to the fragmentation of social life that he foresaw as the eventual terminus of a highly centralized state Socialism. That contribution wasn't just to be found in the fact that science was in a state of crisis at the turn of the century, with a confusing array of new forces and particles challenging the solidity of its theories; nor was it to be found only in the way that Gibbs' theory of gases and the second law itself supported an image of a restless cosmos moving toward the chaos of individual atoms in random motion -- though in this, science modelled in terms of content what it effected, at large in society, through its very form. What was ultimately disruptive in science was its character as epistemology, and what that character implied about ontology -- the structure and order of existence itself. Science confessed human ignorance -- then explicitly condoned an attitude of (in Einstein's words) "unscrupulous opportunism" in regard to the methods by which that ignorance would be ameliorated. This, combined with the pragmatic test of knowledge that meant that "convenience was truth," could have seemed to Henry to be nothing other than a prescription for a sort of ontological anomie. It was this state of affairs, this ontological normlessness, that the Law of Chaos served to model.

But Henry Adams, who otherwise saw so clearly the large and underlying developments in the movement of history, missed one important development that might have offered some grounds for hope. There have been, in the past thousand years, three main phases in the development of epistemology, and Adams saw only two of these phases with any clarity. In the Christian era -- in the Middle Ages that Henry was led to romanticize -- epistemology was grounded in ontology. This grounding survived the first development of science, and the replacement of an essentially religious, organic root metaphor with the religious mechanism of Newton. With the decline of the church as a moral force in the world, with the advent of a morality more firmly grounded in political than religious relations, and with the rise of the focus upon the individual in the political philosophies of Liberalism, ontology gave way to psychology as the foundation discipline for theories of knowledge. This change Henry Adams knew and felt; his appreciation of it lies behind the necessity with which he felt compelled to ground his "point of fixity" in the modern era -- his Education -- firmly in his own individual experience. But of the second major change in epistemological foundations Adams had only an inkling, and it remained beyond his powers to discern its ultimate import. We, however, in the age of Kuhn, can see more clearly that psychology has diminished in importance as a foundation for theories of knowledge as sociological interpretations of knowledge have gained. We can find a glimmer of this perspective in Henry's work --

particularly in what he has to say about Darwinism, and the difference in tenor that history-as-science would take, depending on the era in which it matures[60] -- but no recognition that an epistemology grounded in social and political relations might redress a great many of the ills he identified in the modern world. The reductio ad absurdum of a society that relies upon psychology to light its way to knowledge is a fragmented culture, one in which the only difference between sanity and madness is the successful exercise of political force; but a culture that perceives that knowledge is a product of collective craft, a culture that finds inquiry to be a collaborative, social enterprise, will of necessity be more able to discern in the processes of inquiry a reasonableness, a logos, an "energy not individual" that could form the foundation of non-atomistic, non-"random" human relations. Henry's work points to the modern era as an age of "Brownian" social movement -- individuals colliding with one another, "seventeen million times a second, like an automobile in Paris," with no true hope of ever connecting, of ever coalescing, unless that union be forced through political powers or technological forces.[61] If he had been correct in thinking that our choice lay only between a religious ontology and a secular psychology as the firmament upon which our knowledge and culture stood, he would have been justified in finding no possible path to redemptive, non-oppressive human relations. But we do have a third choice, one represented by sociological interpretations of knowledge.

To use the phrasing we borrowed from Fenichel in an earlier chapter, in Adams' companion works -- the Chartres and the Education -- he was writing about the transition from a world of primary order, grounded in religion, to a world of secondary order, grounded in what looked to him to be the confusions, the anarchy, of politics. Because he romanticized the organic unity of the middle ages, and because he saw clearly that that unity was not a social, political, or economic accident but was instead grounded in the metaphysics of the era, he tended to view politics solely as a realm of coercion and force; he did not see, as the sociology of knowledge affords us the opportunity to realize, that epistemological rules can form the logos of political relations. Unsurprisingly, then, the idea of entropy served as a fit model for the ontological lapsarianism he articulated;[62] the law of chaos captured his sense of what a world must be if within it knowledge is understood to be the result of a political process. The point is, however, that a metaphysic built upon the idea of entropy as root metaphor is only one of several possible metaphysics that give primacy to politics, i.e. only one of several metaphysics that recognize that human concepts of order are human constructs. We need not accept, as Adams did, that politics is necessarily a realm of coercieve use of force, that it obeys no other principles than those of power. As we noted in the first chapter, politics concerns the construction of order, and there are other means to that end than the use of force. (Nor, for that matter, need we accept his vision of the middle ages as having a pure, non-coercive ontological ordering; to a mind grounded in a political metaphysic, the organic unity that Adams celebrated as liberatory would not be as devoid of compulsion as his picture of it suggests. Though the explicit use of force was rarely needed to enforce belief -- at least, not until the Inquisition -- the very fact of consensus suggests to a modern, political mind that a natural diversity of belief was being violated.)

We can summarize these thoughts by concluding that Henry Adams was misled and misleading in his use of the idea of entropy as an organizing scheme for history. While Brooks accepted the validity of thermodynamic concepts as applied to societies and cultures, and then explored the implications of that usage (which is to say, while Brooks was misled <u>by</u> his use of the entropy metaphor), Henry achieved an articulate sense of history outside of the thermodynamic imagery, and then made use of the idea of entropy in communicating that vision (and was misled <u>in</u> his use of the entropy metaphor). Even so, at some fundamental level, Henry was a captive of the entropy metaphor no less than his brother Brooks. In spite of the distance he was capable of maintaining from the metaphor as an organizing device, Henry took as an article of faith the notion that a world devoid of a supervening authority with the power to articulate a vision of order that was not a human artifact was a world plunged into chaos. And that, as we will eventually see, may not necessarily be the case.

Chapter Six

THE NEW PHYSIOCRATS

> Energy may be compared with wealth, and its transformation with the conversion of wealth into different currencies. When we change our money into a different currency we normally lose on the process although the quantity of real wealth in the universe remains unaltered by our transaction.
>
> A.E.E. McKenzie[1]

> The Entropy Law is the taproot of economic scarcity.
>
> Nicholas Georgescu-Roegen[2]

This chapter begins a section of this work in which we look at more nearly contemporaneous uses of the idea of entropy as a unifying, or root, metaphor. The economists I am calling "neo-physiocrats" (the name will be explained shortly) began articulating their thermodynamically-enlightened vision of human productive life in the 1970s -- the second distinct era in which the idea of entropy enjoyed widespread currency and use as metaphor. The late 1960s and early 1970s were, like the 1890s, a time of crisis in American culture, though unlike the earlier time the crisis was not accompanied by economic depression. We are perhaps yet too close to the era to see it clearly -- a fact which might excuse an author from belaboring the history of the period, for it is still within the memory of most readers -- and any general statements made about it are likely to be controvertible. The cultural turmoil of the period took many forms: protests against American foreign policy, claims for greater social justice and economic participation by historically underprivileged groups, the development of a distinctive "youth" culture as baby-boom adolescents came of age and were pandered to by advertising media that recognized their market power, rebellion against and criticism of American cultural institutions in nearly all quarters for having lost sight of the values they were intended to serve. Each of these could be counted as the fundamental dynamic at work in the era, each could be seen as having been the definitive element that gave to a decade, and a generation, its distinctive stamp. And yet to select any one of these, or simply to enumerate them all, is to miss the factor that <u>did</u> give the era its distinctive quality: what defined the period was the fact that all of these dynamics, and others as well, were seen by many Americans to be of a piece, as being various facets of a single, coherent movement that was effecting change. That is, in the 1960s, as in the 1890s, broad-ranging changes in American culture were condensed into a single-issue politic vision that encompassed all issues. In the 1890s, the single issue had been the confrontation between gold and silver; in the 1960s, the single issue was revolution.

Such a reduction of broad-ranging beliefs, critiques, and changes to single-issue politics is the defining element of a period of social, political, and cultural crisis. And because the ability to see connection is the first step in articulating theory, in any time of crisis there is, already, a theoretical perspective, either implicit or explicit, in the belief systems of those who occupy the political stage.

It would be convenient if we could show that entropy as root metaphor formed the foundation of the theory implicit in the cultural changes of the sixties; but what is convenient is not often true. There was a diversity of theoretical perspectives abroad in the sixties -- so many that had either of the Adamses lived to see the decade, either might have taken the era to be confirmation of their theories -- and entropy ultimately figured in only a few of them. But among these were two distinctive visions that rendered elements of the state of crisis itself more comprehensible. The first of these was offered by the novelist Thomas Pynchon, who, in 1966, published _The Crying of Lot 49_, a work that spun into the interstices and vacant lots of the American corporative-technological-industrial experience the myth, grounded in the metaphoric use of the second law, of a redemptive sub-culture. The second, found in the works of the new school of economists we are about to examine, turned to thermodynamics in order to clarify the relationship between human productive life and its context, or, more simply, between economics and nature. In so doing it provided a distinctive foundation to the ecological criticism of industrial culture that had emerged as yet another dynamic late in the sixties. This section, in looking first at these economists and then at the work of Thomas Pynchon, reprises, in a way, the previous section: Brooks' _Law_ was economic in foundation and import, and like the works of the neo-physiocrats, it is founded on a literalist application of the idea of entropy to human activity; Pynchon, who makes obvious his debt to Henry Adams, can be seen as working some of the same ground as the elder Adams in his use of the idea of entropy as the foundation of a mythos for modern society -- though Pynchon and Henry Adams arrived at widely different visions of politics in their use of the metaphor.

Entropy, as a thermodynamic law, reigns supreme over all physical processes in the universe. Our planet, and on our planet our economic activities, constitute no exception to this universality of application. This makes it a peculiar circumstance that, despite the fact that economics counts among its certainties Gresham's Law (which, in holding that "bad money drives out good," bears a marked similarity to the second law of thermodynamics[3]), the discipline as a whole has flourished while totally disregarding the ultimate thermodynamic constraints that set boundaries to human activity. This is all the more surprising, given that economists see their "science" as the rigorous study of "the allocation of scarce resources among competing uses" and as the elaboration of the principles of "constrained optimization," while the entropy law -- the law of "rust, ravage, random and rot," the "taproot of economic scarcity" -- describes the physical process that is the origin of many of the constraints we face and the ultimate source of scarcity. The law of entropy sets limits to our collective ability to garner and to store wealth.

But, it was not always this way in economics, and, if a new school of economics gains the influence it deserves, it will not always be so. This new school of economics promises to bring economics to its senses by refounding it upon the truths of thermodynamics. In so doing, it returns the discipline to its very origins in the work and thought of a group of French philosophes known generically as economistes or (more specifically, after competing schools of economics had developed) as physiocrats.

Physiocracy, as part of the French Enlightenment of the late eighteenth century, was the first identifiable school of economic thought with a recognized leader, a closely-knit group of followers to develop, defend, and disseminate the doctrines of its founder, and a journal through which to accomplish these ends.[4] (The mercantilism it challenged offered no such cohesion, having emerged as a set of general principles generated rather organically from the lore and experience of merchants.) The founder of the school was Francois Quesnay (1694-1774), who may have come to economics out of a concern for the financial, as well as the physical, health of Louis XV, whom he served as personal physician. Quesnay was the product of a rural, perhaps even peasant family. He was never at ease at court, and some find in his doctrine that agriculture is the source of all wealth a deeply ingrained romanticism and a nostalgia for the simplicity of his rural roots.[5] While the doctrines he developed and espoused were further elaborated by others, the influence of physiocracy was short-lived.[6] It reached its peak in the decades from 1750 to 1770, then suffered eclipse for a number of reasons. Quesnay's death in 1774 (and his interest in mathematics late in life) deprived the movement of its founding leader and its court connections, and Adam Smith, who was influenced by the school (having learned its principles first-hand during his trip to the continent as the tutor of the young Duke of Buccleuch in 1763), contributed to its demise with the publication of The Wealth of Nations in 1776.[7] Smith's work, unlike physiocracy, met a receptive audience in the rising merchant and manufacturing class -- people who no doubt viewed with some skepticism the physiocratic doctrine that held them to be an essentially sterile class, incapable of generating wealth. Finally, even those elements of the physiocratic program that were put into effect by Louis XV did not work well: no sooner had export restrictions on farm products been lifted, for instance, than a failed harvest made them irrelevant.

Traditional historians of economic thought, concerned to emphasize the continuity of development in their discipline, point to the contributions that physiocracy made to current economic understanding, and tend to ignore or discount those elements that have not survived. They find in Quesnay's Tableaux Economique the first attempt to model the economy in terms of flows of goods and money, and note its similarity to the input-output table for which Wassily Leontif received a Nobel Prize in 1973; they correctly discern that Quesnay also anticipated equilibrium analysis with his Tableaux; they applaud Physiocracy's effort to rationalize the tax system (though they look askance at the physiocrat's call for a single tax on land, which was the motivating force behind their renovation of the tax system); and they point out that Quesnay anticipated Say's Law of the Markets ("supply creates its own demand") with his dictum, "all that is bought is sold, and all that is sold is bought."[8] The traditional historian is also liable to note that the most enduring contributions of the school have been the motto "laissez faire" and the explicit justification of inequality of distribution of goods and services (then, as now, seen as the inescapable result of individual freedom combined with rights to property).[8] These historians, by emphasizing these points of continuity, lead us away from appreciating the doctrines of the physiocrats as a coherent, integral whole; they also lead us away from just those elements of physiocracy that most deserve to be recovered: the distinctly un-traditional views on the origins of wealth, and the willingness to mesh economic doctrine with the insights of physics.

Physiocracy means _rule_ _of_ _nature_, and Quesnay understood the system he espoused to be firmly grounded in the truths of physical science. He accepted the then-prevalent analytic distinction between natural and positive law, and (like other _philosophes_) thought that much remediable evil came about when the latter did not reflect the former. His call for "laissez faire, laissez passer" was a mark of his confidence that, when once unburdened from debilitating regulation and restraint, economic life would "naturally" tend to mirror the truths of natural, physical law. In social affairs as well as in the universe at large, those laws were discoverable by reasoning from "self-evident" principles, and there was no disjunction, no inconsistency between the two types of law: "to the physiocrats the natural order of society was a branch of physics."[10]

Quesnay, then, did not see himself as incorporating into economics metaphoric truths "borrowed" from physics; as a Cartesian and a follower of Malebranch, he saw the cosmos being ruled by law, a machine arranged in hierarchical and harmonious order, its parts meshing -- in the absence of external interference -- perfectly one with each other. The image of the clockwork cosmos explains, in part, his call for a minimum of governmental interference, as does his suspicion of commerce, his belief that it was a sterile activity, incapable of producing any net value, and his consequent willingness to relegate it to a minor category in his ordering of economic activity. He did not foresee the tremendous growth in mechanized production that was shortly to take place, and so could not have anticipated the modern roles of government as nightwatchman, referee, or handicapper. Quesnay was an economist of a world with limits, a world still rooted in the agricultural experience; Smith, a scant decade or two later, would be the economist of the emerging industrial enterprise and the social chaos it brought in its wake. (Quesnay's doctrine of _laissez faire_ also is consistent with his beliefs about how science proceeded. The elegant deductive systems he imagined to be at the heart of science assume that mind pursues its own course, and in so doing models, through the laws and principles it discovers, the order of nature. This vision contrasts sharply with more recent views, in which knowledge is seen as the product of an event in which the knower and the known partake in equal measure.) While the physics upon which Quesnay based his economics is dated, both in its mechanistic content and its deductive method, there remains here a willingness to integrate economics as a discipline into a larger picture revealed by physics, and this is a characteristic that the neophysiocrats would redeem today.

While the physiocratic call for laissez faire was voiced in a world much different from ours, their idea of the origin of wealth remains relevant today -- though it stands in need of some modification. Quesnay believed that agriculture alone was the source of wealth: "The earth," he declared, "is the only source of riches, and it is agriculture [alone] that multiplies it....The origin, the principle of all goods and all riches is the fertility of the earth."[11] Such "sterile" classes as manufacturers (artisans) and shopkeepers exist only because of the surplus created by agriculture, which is a "gift of nature." A given quantity of seed will reproduce itself, and more besides -- enough more to feed the farmer and some livestock (which also reproduce more than their number), and still have enough left to trade for rent (to the landlord class) and to purchase implements and manufactures. Agriculture's status as the unique producer of "produit net," then, had to do with (as Quesnay saw it) the fecundity of the organisms in its care. Whatever value manufactured articles had, they had by virtue of being created by beings who consumed agricultural produce. In an insight borrowed later by both Ricardo and Marx, Quesnay held that "the value of the industrial goods is proportionate to the value of the subsistence which the workers and merchants consume." But Quesnay went the further step of finding in that proportion an equation -- one that held no matter what the prevailing wage or price level was. "Thus," he continued, "the artisan detroys in the form of subsistence as much as he [sic] produces by his labor," and the artisan's activity has no net effect on the wealth of the nation.[12]

"Physiocracy," one modern critic tells us, "is...a rationalization of medieval economic life." Quesnay, like Henry Adams after him, was drawn to the past, to a romanticized vision of the simplicity and unity of medieval life. It might be only coincidence that we find in Quesnay as well as in Adams both a fondness for the past and a social critique connected to the second law of thermodynamics. In Quesnay's work, of course, the second law is not explicit: he wrote well before Carnot's first faltering attempts to articulate a science of heat. But Quesnay anticipated remarkably well a perspective available to us through thermodynamics, first made explicit in the work of Julius Mayer: all life and all energy on this planet (with the recent exception of nuclear power, and some few geothermal sources) are traceable, ultimately, to the sun, and energy has something to do with what we humans count as valuable. In this vision, green plant life is the great net by which the planet captures solar income and converts it to forms that animal life finds useful. Agriculture is the attempt by humans to transform a flow of energy into an apparently more reliable stock; it is one of the primary sources of terrestrial "low entropy." While ignorant of the language and conceptual framework of thermodynamics, the physiocrats modelled their economic thought as if they knew this truth, and were led to idealize a simpler, agricultural past.

Modern day physiocracy, well aware of the laws of thermodynamics, adds to agriculture one other sector of the economy that provides human culture with a net low entropy gain: mining. Agriculture and mining are the only two activities that can provide this net "negentropic" product.[13] To see this, we need to discuss what Nicholas Georgescu-Roegen wants to call the fourth law of thermodynamics.

Georgescu-Roegen proposes the following language for a new fourth law of thermodynamics: "No [materially] closed system -- i.e. no system that can exchange only energy with the outside -- can perform mechanical work at a constant rate indefinitely."[14] Whether or not we grant that this should be a new fourth law of thermodynamics (I think it more properly a corrolary of the second law) Georgescu-Roegen is clearly disagreeing with those who, along with Kenneth Boulding, believe that "there is, fortunately, no law of increasing material entropy."[15] If the entropy process did not apply to matter as well as to energy, then material goods would never wear out or need replacing, and the conditions of scarcity under which we humans labor would be much ameliorated. But in fact matter does degrade entropically: molecules wear off the coins we handle, dissipating so completely that we can scarcely even imagine a process, however energy intensive, for collecting them together again; our automobiles wear out with use (or even when not used, as they succumb to rust and rot), requiring us either to abandon them or to replace their worn parts with new ones -- a practice that amounts to the importation of material into the systems they represent. If there were no law of increasing material entropy, an engine would run indefinintely as long as it was supplied with fuel. But every engine requires periodic repair and maintenance, every engine loses crucial molecules to the ordinary processes of wear and tear. The ultimate high-entropy state for matter on the planet, corresponding to the ultimate heat death of the universe, would be an homogenous admixture of the molecules of everything with everything. That we are obviously so far from this ultimate end (and that there are geological processes that move us further from that end) does not mean that the process of material dissipation does not exist, or that it does not affect us. The planet offers us a finite quantity of high-grade stocks of ore of the materials we desire, and when these are exhausted we must turn to increasingly lower grade ore deposits. Lower grade ore deposits offer us smaller concentrations of the materials we seek, and therefore require more manipulation, more energy, to be transformed into the desired substance. We need only to recognize that the language of "concentration" and "dissipation" is the language of the entropy law to realize that high-grade ores are pockets of low entropy, and to see that mining is an activity that can bring to an economy a net gain in low entropy.

Neither Nicholas Georgescu-Roegen nor Herman Daly, the two prime movers behind the neophysiocratic movement, make much of the physiocrats as precursors of their vision.[16] Daly, however, seems to be embarked on a campaign to rehabilitate single-handedly the reputation of another economic thinker who grounded his work in the laws of thermodynamics, and who may serve just as well as an intellectual progenitor of neophysiocracy: Frederic Soddy.[17] In two recent articles, Daly writes of Soddy's economic writings, defending their contemporary relevance, and pointing out that Soddy anticipated the recent contributions of Georgescu-Roegen in "providing economics with a partial foundation in thermodynamics, the physics of usefulness."[18] Soddy is best known for his work as a chemist on radioactive decay and atomic theory, for which he received the Nobel Prize in 1921, when he was forty-four. But during the second half of his long life (he died in 1956) Soddy turned his attention to economics out of a concern about the nature of the social world that received the inventions of science. He realized (earlier than most) the theoretic possibility of nuclear power, and worried that this apparently great advance would become, like the poison gas that modern chemistry helped to produce, another instrument of war, unless structural deficiencies in the world's political and economic systems could be corrected.[19] His entrance into economics is a textbook case of Kuhn's views on change within scientific fields: he viewed economics with eyes untrained in its dogmas, and therefore saw some phenomena more clearly while remaining ignorant of some of the fundamental principles established in that discipline that might have helped him communicate with economists.[20] He regarded other economists with "undisguised contempt" and "the contempt was mutual;" while he considered economics to be a psuedo-science for its ignorance of thermodynamic truths (and must have felt himself to be in the position of the child who noticed the emperor had no clothes), he was widely regarded by economists and others as a good chemist gone bad, "a 'crank' on the subject of monetary policy," a man fanatically devoted to the premise that the root of all evil was to be found in the fractional reserve banking system -- which, he believed, was based on a hopelesss attempt to overcome the second law of thermodynamics.[21]

The fractional reserve banking system is the mechanism by which private banks create money. When a deposit is made to a bank, the bank will, if it is efficient, soon lend out that money at interest, holding in reserve a certain fraction (specified by the regulations of the Federal Reserve Board) against the expected demand for cash by its customers. The person receiving the loan will, most likely, deposit it in a bank (or spend it, in which case it soon ends up in a bank somewhere), where, again, most of it will soon be dispatched as a loan. In this way, an initial deposit of one hundred dollars will become, at a fractional reserve rate of twenty percent, an increase in the monetary balances of the system of nearly five hundred dollars. Economists marvel at this system whereby the money supply of an economic community can increase "naturally;" Soddy marvelled at the insanity of a system that totally disconnected an abstract symbol -- money -- from the real, physical entities -- the wealth of the community -- it was supposed to represent. The creation of real wealth, he believed, was ruled by the laws of thermodynamics; ultimately wealth is some form of low entropy, and our capacity to increase our stock of it is necessarily limited. The supply of money, however, has no such natural limitation: it can increase by leaps and bounds, geometrically, infinitely, by government fiat, by regulatory whim. Under fractional reserve banking, "banks are like counterfeiters who lend false money, accept their own false money in repayment and destroy it, but receive the interest in real money [which is] transferred to them by the rest of the community, [and]...is not destroyed."[22] Soddy called money "virtual wealth" to distinguish it from the real (physical) article, on the one hand, and from debt, on the other. In order to avoid the inconvenience of barter, some form of money is necessary. But the money is not wealth; it represents real wealth forgone by the community so that it may have a medium of exchange. It is "the aggregate value of real wealth which individuals in the community voluntarily abstain from holding in order to hold money instead."[23] If everyone tried to convert their money holdings into real wealth, they would soon discover that an exchange system is like a game of musical chairs: someone must, in the end, wind up holding the money.

As Soddy saw it, the major economic confusion of the present era is a confusion of wealth with debt. Wealth is a physical entity, subject to the law of entropy, while debt is an imaginary concept, subject only to whatever conventions we choose to impose upon it. "Unlike wealth...debts do not rot with old age and are not consumed in the process of living. On the contrary, they grow at so much per annum, by the well-known mathematical laws of simple and compound interest...."[24] The "ruling passion of the age" is the passion to convert one into the other -- to trade real, currently held wealth for debt, a claim against the future income of the economic community. Those who have a surplus of current real wealth will want to do this in order to secure their future income. No one can accumulate all the real wealth they will need in their old age; it would decay or rot long before it could be used. By exchanging real wealth for (and holding instead) debt, a person can seemingly secure their future well-being.[25] But claims against future production can increase geometrically, or infinitely, while the real wealth that the claims are made against cannot do so for long; the amount of low entropy that an economic system can appropriate is limited, which means the rate of growth of the rate of appropriation must ultimately be limited. Thus, Soddy was led to see that some form of debt repudiation -- bankruptcy, inflation, confiscatory taxation -- was a structural necessity in order to re-establish the necessary one-to-one correspondence between real wealth and money, the medium of exchange that represents wealth and the vehicle through which debts are held. As Daly puts it, conventional economic wisdom sees these processes of debt repudiation as pathological, but accepts as normal the process of compounding interest.[26] "Logic demands, however, that either we constrain compound interest in some way, or accept as normal and necessary one or more of the counteracting mechanisms of debt repudiation."[27] Soddy tried to show us, Daly says, that the current state of affairs is "a vulgar delusion on a grand scale," and that the idea that we can live off our mutual indebtedness is "just another perpetual motion scheme" doomed, ultimately, to failure.

Along with his diagnosis, Soddy presented some ideas for reform: he believed that the reserve requirements for banks should be set at one hundred percent (and that banks should make their income, not through the creation of money, but by charging for the legitimate services they do provide), that international exchange rates should be allowed to fluctuate freely, and that the government should expand or contract the money supply by issuing or destroying "fiat money" only in order to achieve stability in prices. This latter process was designed to correct a serious deficiency in the system: the "naturally" operating processes at the time that Soddy wrote (and by no means fully corrected today, in spite of the principles of Keynsian deficit spending) tended to inflate the money supply during boom times and to contract it during recessionary periods, thereby aggravating rather than ameliorating the "boom and bust" cycles of the economy. (Soddy was also among the first to call for a government-monitored price index to make this task easier.) Of these major reforms, one is now fully realized (floating exchange rates), and another is recognized as desireable but falls short of realization, given the structure of our electoral politics (which makes it difficult for a democratically responsive regime to contract the money supply, even in times of inflationary pressure). Only Soddy's third proposal -- the one on which he himself place the most emphasis, in the knowledge, perhaps, that it would be the least likely to be accepted -- has been totally slighted. If Soddy is right -- if the institutions of compound interest and fractional reserve banking represent attempts to circumvent the second law of thermodynamics, and if nations are ultimately led into conflict with other nations in an attempt to avoid having to balance the resulting disproportion between national wealth and the claims upon it -- then it just may be that whether science emancipates or destroys humanity (the question with which Soddy started) depends on what he admitted was an apparently "minor technical point in a banking system," the size of the reserve requirement.[28]

The practice of loaning money at interest that lies behind the fractional reserve banking system is so deeply ingrained in our modern world that it is easy to forget that it has not always been accepted practice to charge for the temoporary use of money. The practice, while known among the Greeks, was condemned by no less an authority than Aristotle, who seems to have agreed with Quesnay that wealth has a _natural_ source, and that commercial activity was "justly censured" as an activity by which people "gain from one another" rather than from the true sources of wealth. For Aristotle, usury was "the most hated sort" of the ways to make money commercially; "Usury," he wrote, "makes a gain out of money itself, and not from the natural object of it. For money was intended to be used in exchange, but not to increase at interest."[29] Aquinas, too, added his voice to the argument against the practice of charging interest, enumerating it among the sins of commerce.

"...[T]o receive usury for money lent is, in itself, unjust, since it is a sale of what does not exist; whereby inequality [of exchange, and hence injustice] obviously results."[30] (Usury here has its older meaning, encompassing any lending of money at interest; the word has in recent times changed in meaning, so that now it generally refers to the charging of excessive interest.)

The physiocratic call for the abolition of the practice of charging compound interest -- a doctrine advanced by Soddy, and only implicitly supported by Daly -- thus has precedent, and is not as heterodoxical as it might, at first, appear. And yet the mere fact that both Aristotle and Aquinas felt impelled to discuss the impropriety of usury shows that the practice was known in their day. (The origins of money and of banking practices, like those of civil society, recede in the mists of time, and are only partially illuminated by state-of-nature conjecture and deduction.) It seems unlikely that physiocracy can successfully challenge a human convention of such long standing; but if it is to do so, it must successfully controvert the two main defenses that are offered for the practice of charging interest.

The first of these is the market price argument, which simply holds that interest is the price of money. If money were not scarce, this argument suggests, perhaps then it would be a "free" good; but then, in that case, the prices of all other goods would be sharply inflated. As long as money is both useful and scarce, it will have a price. This argument helps illuminate the origin of the practice of charging interest, but it requires that we accept the idea that money is a commodity like any other -- which is just the point that Soddy was so concerned to disallow. Of the two sides to the disagreement, one side has the weight of tradition, custom, and history arrayed with it; the other side -- the physiocratic side -- relies on the authority of thermodynamics to bolster its case. If sanity prevails, the insights of physics ought to weigh more than tradition here, in supporting the view that money is a symbol and not a commodity. The case is further confused by our modern credit economy which is no longer tied to the physical markers that we use as money; most members of the middle and upper economic classes can enjoy as many goods and services as they care to, now, in exchange for the promise to pay a major credit card company eighteen per cent per year on the balance. Those of us who accept the rather narrow view of economic rationality that economists employ would be fools not to go into debt as far as possible, if Soddy is right in his analysis of the structural necessity for some form of debt repudiation. Unfortunately, what is economically rational for an individual turns out to be thermodynamically insane for the collectivity.

The second defense of usury was eloquently stated by Sir William Petty, the seventeenth century mercantilist: "...when a man giveth out his money upon condition that he may not demand it back until a certain time to come, whatsoever his own necessities shall be in the meantime, he certainly may take a compensation for this inconvenience....And this allowance is what we commonly call usury."[31] This is the opportunity cost defense of usury, which sees the interest charged as compensation for the lender's deferred gratification and risk. It seems to me to be challengable on two fronts.

First, Petty's language clues us in to the fact that the relationship he is talking about is one between strangers, or at best unfamiliars: between friends and family, one hardly speaks of "demanding" things, or of total prohibition of certain requests, or of sticking to an arrangement made when the circumstances surrounding it have altered. Just as it is unlikely that many people loan money to corporations or banks without expecting interest, I suspect that few people loan money to friends with the expectation of receiving interest. This suggests that the institution of interest is part and parcel of the general de-personalization and institutionalizing of our financial affairs, and that a return to less formal structures to achieve temporal redistribution of individual income (from the future to the present, on the part of the borrower, and from the present to the future, on the part of the lender) might reduce the burden of economic growth we are placing on the future.

Second, some ecologists have taken modern culture to task for its tendency to discount the future -- a tendency aptly summed up by the sullen quotation Robert Heilbroner uses as a chapter title: "What Has Posterity Ever Done for Me?"[32] The notion of deferred gratification (the idea that jam tomorrow is not worth as much, today, as jam today) is another aspect of our tendency to deny the full force of reality to the future, to embed ourselves in the narrow moment of the present -- and once again the idea of entropy has led us (this time through a rather circuituitous route, through economics and physiocracy) to a consideration of our notions of time. It is clear that if physiocracy is to challenge successfully the practice of charging interest it must somehow transform our society's ordinary, everyday sense of time, and our resulting belief that pleasures postponed are pleasures incrementally forgone (at a rate that varies from, say, four to twenty-four percent). Physiocracy might lead us to a new appreciation of time by leading us back to agriculture -- one of the two main sources of wealth -- and the cyclical notion of time that can be forged from an appreciation of natural rhythms and cycles manifest in the changing of the seasons. Here, though, we see entropism --the larger world view suggested by the idea of entropy, of which physiocracy is a part -- skewered on a paradox: the law of entropy is the law of linear time, and an economic system grounded on its truth may require, as an ontological _sine qua non_ of its existence, a widespread acceptance of a cyclical notion of time.

For whatever reason, Soddy chose to represent his criticism of orthodox economics through a program that stressed a single point -- the evils of fractional reserve banking -- as its centerpiece. Contemporary physiocracy neither offers nor allows us such an easy distillation of its perspective, unless it be contained in the general injunction to ground economics, as a practice and as the study of that practice, in the truths of thermodynamics. Neophysiocracy offers us a plethora of particular insights and suggests a set of new principles -- some modelled on the methods of energy accounting developed under the principles of the first law of thermodynamics, some derived from a thoughtful application of the truths of the second law to the economic activities of humans. In what follows I shall attempt briefly to sketch the main outlines and some of the particular insights of neophysiocracy as an economic perspective, before turning to an evaluation of neophysiocracy as the foundation of an ecological perspective. (Any survey of neophysiocracy ends up being, almost exclusively, a survey of the work and thought of one person, Nicholas Georgescu-Roegen. Others have made minor contributions to the field, but Georgescu-Roegen alone has undertaken to unify the various threads of thought that thermodynamics suggests in economics and to bring them together in a consistent whole. His work is "more praised than read," and he himself is more honored than heeded, but it is no exaggeration to call his major work -- <u>The Entropy Law and the Economic Process</u> -- "our generation's classic in the field of economics" or to suggest, as did Paul Samuelson, that his ideas "will interest minds when today's skyscrapers have crumbled back to sand."[33] In what follows, then, I shall rely heavily on the work and thought of Georgescu-Roegen.)

The new physiocracy suggests that the "macro" view taken by traditional economics is not quite macro enough. Traditional economics divorces economic activity from its physical grounding, its physical context, while (somewhat) blithely and (very much) implicitly assuming that economic activity is ahistorical (i.e., economic activity does not irreversibly change the physical milieu in which it occurs). Traditional economics, then, models the economy as a closed system -- "a circular flow between production and consumption with no outlets and no inlets," "an isolated, self-contained" process, a "'no deposit, no return' affair in relation to nature."[34] Neophysiocracy would have us step a little further back, as it were, and see an economy as an open system -- one which, like any living cell, or any plant, or any animal, takes in low entropy in the form of matter and energy across its boundary and discharges high entropy into its environment.[35] The consumer goods we produce, which are highly organized pockets of low entropy, are produced only at the cost of creation of a larger increase in the entropy of the system from which they arise. To the economic principle, "there is no such thing as a free lunch," neophysiocracy adds a rider: in entropy terms, the cost of a lunch is always greater than its price.[36] And manufactured articles are but temporary orderings of molecules that will ultimately succumb to the law of entropy and become waste: today's washing machine becomes tomorrow's reddish-orange iron oxide smudge on the surface of the earth. Thus, from this perspective, "the economic process materially consists of [nothing more than] a transformation of low entropy into high entropy, i.e. into waste."[37] This suggests both that "the true 'product' of the economic process is not a material <u>flow</u> [of goods, as traditional economics would have it], but a psychic <u>flux</u> -- the enjoyment of life," and that pollution -- the "output" of waste or high entropy -- is an unavoidable consequence of economic activity.[38] Both of these insights contradict orthodox economic thinking, which, in spite of its recognition that the immaterial flux of "utility" is the goal that drives economic activity, shows a great willingness to measure the benefits produced by an economy solely in terms of the monetary value of the goods and services it produces. The orthodoxy also tends to define pollution as "resources out of place," and to assume that outputs (as well as inputs) are infinitely substitutable at the margin -- i.e., that given any quantity of pollution, that quantity can be reduced by dedicating more resources to its elimination. Orthodoxy tells us that at some point the returns we get on such an "investment" are not worth while, and so explains the existence of pollution by reference to this decreasing return at the margin. Neophysiocracy tells us that the existence of pollution is not a matter of choice: it is a thermodynamic consequence of economic activity.[39]

The hope that recycling can solve the pollution and scarcity problems created by industrial production depends, ultimately, on this orthodox, closed-system view of economic activity. The neophysiocratic view is somewhat gloomier: recycling, while a valuable component of any program to reduce the rapaciousness with which the modern world economy gobbles up scarce low entropy, is no panacea. This is because recycling requires energy -- the one factor of production that we cannot recycle. Because the law of entropy prohibits the recycling of energy, "the Entropy Law is the taproot of economic scarcity." If we had an infinite supply of energy, we might undertake to recycle all the low entropy stocks of matter that we use -- down to the very molecules that wear off our coins. But given limited energy sources, that would be prohibitively expensive in entropy terms: the amount of low entropy we would gain in the form of organized matter would be more than outweighed by the low entropy we have given up in the form of energy. For this reason, "dissipated matter cannot be recycled; we can recycle only what we may call 'garbojunk' -- scrap paper, used aluminum cans, used cables, etc."[40] There is no getting around the fact that an economy requires the importation of material low entropy, which is scarce; an economy cannot be a closed system, perpetually recycling the materials that make up its finished goods.

The form of accounting implicit in the above discussion needs to be made explicit, for it is another key element in the perspective of the neophysiocratic school. Everything that is produced within an economy has an entropy cost associated with it -- including, of course, quantities of low entropy. Again, among human activites only mining and agriculture make available more low entropy than they consume; every other phase of the economic process represents a net loss of low entropy to the economic system.[41] This sort of accounting is known generally as "net energy" accounting, though Georgescu-Roegen proposes that it is nonsense to speak of "net energy" or "net matter." What we may speak of is <u>accessible</u> energy and <u>accessible</u> matter.[42] If a certain stock of mineral energy -- oil shale, for instance -- requires more energy to garner, store, transport, and use than we could ever expect to get from it, then that stock of energy is inaccessible to us. Over time, as the most accessible stocks of low entropy are used first, the low-entropy cost of low entropy increases -- and this trend stands alongside the process of debt repudiation that Soddy identified as another dynamic that produces systemic inflation in an industrial economy. There is, in this perspective, a none-too-subtle suggestion that low-entropy cost is a better indicator of value than economic or monetary cost, and a strong justification for whatever governmental policies would be necessary to bring the two into harmony.[43] If the production of one economic good requires twice as much low entropy as the production of another, that ratio should be reflected in the ratio of their monetary prices.[44]

Ever since the Reverend Thomas Malthus published his predictions concerning the ability of population growth to outstrip advances in food supply, economics has been known as "the dismal science." It is a nickname that has been, for most economists of late, more quaint than deserved, for orthodox economists of every ideological stripe -- Marxist as well as mainstream -- have competed with each other in offering the rosiest vision of future economic growth.[45] The experience of the past two decades has led more and more people to question those glib assumptions about infinite growth, and to realize that Malthus has never been satisfactorily answered. The rise of the "limits to growth" movement and the continuing articulation of theories of "steady-state" economics are signs that we, as a species, may yet come to recognize that there are certain constraints, not of our own making, within which we operate and which we ignore only at our peril. The new physiocracy can be seen as an attempt to give this new economics a firm, rigorous grounding in both physics and biology.[46] It suggests not only that there are limits to economic growth (and to recycling), but that economic activity itself will of necessity be of finite duration: the steady state, in this vision, is as much a chimera as the infinte growth economy. This is because economic activity at any but the simplest level depends on stocks as well as flows of low entropy, and these stocks are scarce. Technological progress has (so far) consisted of replacing a relatively abundant flow of low entropy -- solar radiation -- with more limited stocks of low entropy -- the earth's mineral resources -- in our economic "recipes" for production.[47] As we use up our planet's low-entropy "capital," its "dowry" of valuable resources, we ensure that there will be less of everything for populations of the future. We are sacrificing not only the luxury of future populations, but perhaps even their very existence, given that we are also using up the fertility of the soil through our fossil-fuel based agricultural technologies. Georgescu-Roegen tells us that an ancient bit of Romanian folk wisdom has it that "horses eat people," which shows that in at least one region a non-technologically developed agricultural people intuited that there were limits to our ability to garner and to store low entropy, and that the very "tools" they used competed with them for it.[48] We have replaced the peasant's draft animals with machines, which, instead of competing with humans for the limited solar income available to the farmer, represent an intensive use of the low entropy available in the earth's mineral stocks. The "mechanical buffalo," made of iron ore and coal, exhausts and excretes materials that are not at all as useful to the farmer as the real buffalo's manure; consequently, use of the machine also entails use of fossil-fuel based fertilizers. The short run "problem" -- which had been defined as scarcity of food and fodder rather than an excess of humans -- is solved, only at the cost of creating a form of agriculture that substitutes reliance on a relatively more plentiful flow of low entropy for reliance on relatively more scarce stocks of low entropy. (Our modern attempt to convert liquid fuels into food calories may well be viewed by future generations as a crime, since they will, in all likelihood, be very busily engaged in trying to do just the opposite.) This is low entropy that will not be available to future generations. Tractors eat people too, then: people who are not born yet.[49] "Every Cadillac produced at any time means fewer lives in the future."[50]

Georgescu-Roegen's apparent pessimism[51] does not prevent him from offering a prescription for "bioeconomic" sanity. His "Minimal Bioeconomic Program" contains these eight points: cessation of production of instruments of war as a sheer waste of valuable resources; reduction in the gap of standard of living between developed and undeveloped nations; reduction of population to a level that can be supported by organic agriculture; avoiding ("by regulation, if necessary") all waste of energy; elimination of "our morbid craving for extravagent gadgetry;" revision of our attitude towards fashion and style, with a premium being placed on goods being durable and servicable, rather than merely new and trendy; redesign of consumer goods so that they are not only durable but repairable; and finally, recognition of and escape from what he calls the "circumdrome of the shaving machine," in which one shaves faster so as to have more time to work on a machine to shave faster so that one may have even more time to work on a machine that shaves still faster.[52] What strikes one about these prescriptions is that they are neither particularly novel (though they may have had more of the force of novelty when first published in 1972), nor very daring (Soddy offered stronger medicine than this), nor very obviously derivable solely from a knowledge of thermodynamics (similar reforms have been advanced and defended by people who make no mention of the law of entropy). A less cautious program, more obviously rooted in thermodynamics, might call for policies that would raise the cost of non-renewable low entropy (i.e., the products of extractive industries) to something like their true, negentropic value -- whatever that might be. (How does one arrive at a just price for something that is irreplaceable? Georgescu-Roegen notes that the market alone won't work, because market prices are temporally parochial: they don't include the "bids" that future generations might offer for scarce low entropy stocks. Because of this, it is clear that current prices are horribly depressed.) Such policies would give an effective (meaning monetary) spur to what is, in Georgescu-Roegen's program, merely hortatorical: the avoidance of waste and the revision of our attitudes about fashion and gadgetry.

Such policies would also aggravate, rather than ameliorate, current disparities in income distribution and the problem of poverty, unless the taxes on extractive industries were returned as grants to those with low incomes. Even so, these policies would be unpopular, and so are not likely to be initiated by a public authority, unless an informed and concerned populace demands to be forced to be constrained in such a way. There is a distinctly Hobbesian cast to this line of thought, and if neophysiocracy pursues this sort of advocacy, its voice will join those of the many other environmentalists who see no solution to our current ecological plight without greater centralization of political authority, more central planning, and an enforced harmonization of human activity with its physical milieu.[53]

But there is, among environmentally concerned people, another strand of thought, the decentralist vision, and it seems equally possible to wed the physiocratic program to it. Because solar radiation is diffuse, its capture is most effective if decentralized (high-tech, centralized demonstration projects notwithstanding). A physiocratic economy, based on solar flow and renewable energy sources, would thus of necessity make use of many, small-scale, locally operated energy collectors.[54] The political institutions consistent with such an energy infrastructure would be the ones suggested by what Arne Naess has identified as a principle of an ecological consciousness: decentralized, locally autonomous units, perhaps loosely federated, each of which holds forth the possibility of meaningful participation to the citizens who comprise it.[55] This is Jeffersonianism -- but, notwithstanding that Jefferson was influenced by the physiocrats[56] (who seemed to intuit a thermodynamic truth), and that an energy activist of the stature of Amory Lovins counts himself as a modern day Jeffersonian,[57] thermodynamics as a science has no content that is directly applicable to questions of political organization. There is something much more akin to metaphor than to logical derivation in the suggestion that a decentralized political structure is "consistent with" a decentralized technology for the garnering and delivery of low entropy. There is a delicate web of relations here among physiocracy, public policy, political organization, and morality, and I will endeavor to sort them out.

To begin with, we should recognize along with Georgescu-Roegen that the idea of entropy, while an important concept capable of drastically revising our economic practice, is not especially illuminative when it comes to problems of social and political organization.[58] Georgescu-Roegen also sees that a thermodynamically enlightened economics does not encompass the whole of ecology: economics "will have to merge into ecology, if the merger ever occurs," for "the phenomenal domain covered by ecology is broader than that covered by economics."[59] His hesitancy to prescribe social and political forms, and his willingness to grant a larger scope to ecology than to economics, is a mark of the limited purview he wishes to hold for economics. Except for the general prescriptions in his bioeconomic program, Georgescu-Roegen seems willing to accept the traditional image of economics as a purely descriptive, non-normative science. Despite the obvious implications of his view for public policy and individual deportment -- despite the bridge over the fact-value dichotomy that the second law offers us, the bridge that was so obvious to Ostwald -- he refrains from elaborating neophysiocracy into a moral code.

But economics is not simply descriptive, and never truly non-normative. Behind every economic system is an image of the appropriate relationship between humans and nature, and of the "natural" form for relations among humans to take. Humans have always turned to the natural for guidance in moral questions (even when their explicit aim was to distinguish themselves from nature, they took guidance from nature as the antithesis of the conventional), and the thermodynamic perspective manifest in physiocracy promises to be no different. Just as utilitarianism was the moral theory most integrated into classical political economy, "what might be called the BTU theory of value" may be the moral theory most befitting a world that understands its economic life in thermodynamic terms.[60] It is not a particularly good moral theory; in it, the caloric nexus would replace the cash nexus that Marx criticised. Instead of having a world in which money is the lowest common denominator, we shall reduce everything to an "entropy cost" measured in calories, BTUs, foot-pounds, and the like. This moral theory already grants a measure of self-righteousness to those who prefer less energy-intensive activities to activities dependent on the burning of fossil fuel (cross-country skiing over downhill skiing, jogging over motorized "sports," acoustic, "live" music over electric or recorded music, etc.), and seems to be the view implicit in the preferences expressed by many within the ecological movement: hand-made and home-grown over store bought, wooden and "natural" over plastic and "artificial," old and servicable over new and shiny, the hand-cranked, horse-pulled, or wind-propelled over the electric, the motorized, the fossil-fuel-combusting. In this movement, nostalgic though it is, may lie our species' hope for the future. But there is more to this mindset, more to this moral universe, than can find expression in a rhetoric that suggests that the moral choice lies in the action that conserves the greatest number of calories in the greatest number of ways over the longest period of time. "Right livelihood" -- to use a phrase from Schumacher[61] -- may well be a livelihood that tends to conserve scarce low entropy, but calorie counting alone is not the path to that state of ecological grace. In fact, far from being a necessary but insufficient precondition to an ecological consciousness, a moral theory built upon the "calculus of caloric" may be a step in the wrong direction: it promises to leave us, as a culture, just as emotionally and spiritually paralyzed as the Benthamite "calculus of felicity" did John Stuart Mill.[62] This is because some human activities are not amenable to rational, quantified analysis of any sort -- deep emotional attachment and appreciation of art spring to mind -- and because the injunction to "waste no energy!" is a stern, totalitarian principle. Were one to take it seriously, one would be morally obligated (for instance) to experience only that art that was personally most "energizing"; second best simply would not do. Paralysis comes, within this moral universe as well as in the Benthamite one, through ignorance: if one does not know in which direction the most efficient use of "energy" lies, if one does not know which path contributes the maximum surplus of pleasure over pain or the minimum surplus of pain over pleasure, one seems morally obligated to do absolutely nothing. It is, on the whole, more realistic to recognize that education itself often involves pain and (a different matter) the waste of energy in the suffer through of experiences we thereupon learn to avoid.

To summarize, then: physiocracy suggests some prescriptions for public policy that are ecological in their import; in so doing it suggests a moral vision that is distinctly unsatisfactory; and it reaches the issues of political organization only vaguely, if at all. But this is not to say that entropy as root metaphor, as that root metaphor is manifest in economics, is a <u>bad</u> thing; only that it is limited. If ever there were a discipline that <u>ought</u> to be made over in the image of the entropy metaphor, that discipline is economics. As long as we consider economic life alone, a general re-casting of our thought and action attendant upon an appreciation of the limits set by the laws of thermodynamics promises only to help and not to harm. But this is more of a sign of the tremendous distance that the discipline of economics has to go in order to enter the age of ecology than a testimonial to the value of entropy as root metaphor. There are limits to what a thermodynamically enlightened economics has to offer. Neophysiocracy, as Georgescu-Roegen formulates it, perpetuates some of the soul-deadening characteristics of the modern industrial system: the idea that work is, fundamentally and unavoidably, a "disutility" to be avoided if possible, rather than a possible avenue to self-affirmation and self-worth (as it might be, if performed in an appropriate context of social and economic conditions); the notion that "enjoyment of life" flows from the garnering of low entropy in the form of ownership and use of material articles; and the fragmentation of individuals into individuals-as-producers and individuals-as-consumers, a dichotomy from which flow some of our era's least enlightened, least authenticating, most oppressive managerial practices.[63] Economics will not enter the age of ecology until it can recognize that the processes it studies are the activities of people who have aspirations to being whole, authenticating, and integrated; the abstractions of _homo entropicus_, the human who does not waste calories, bring us no closer to that goal than did the abstractions of _homo economicus_, the human who does not waste money.

All this amounts to a criticism that physiocracy still treats economics as the study of the means and manner of humanity's _physical_ interaction with nature, to the relative neglect of the psychological, social, moral, and sublime aspects of that relationship as it is manifest in human productive life. Physiocracy is capable of showing us how to bring one aspect of the life of the polis -- human productive activity -- into a more ecologically enlightened relation to its physical milieu. But economic relations are not the sum total of ecological relations, and a world view so resolutely focused on them reaches other, more encompassing relations only with difficulty. Because it remains silent about the many other sorts of relations that an epic political philosophy must comprehend (those between individuals and between individuals and the collectivity) physiocracy remains a strictly economic theory. Nor is it the integration of economics into ecology that Georgescu-Roegen himself recognized was necessary, for the bridge that physiocracy offers between facts and values, is and ought, journeys squarely and solely through the caloric nexus, which is only one of several ways of conceiving relations that the study of ecology offers us. It's good economics, but economics nonetheless, and therein lies its shortcoming.

Chapter Seven

POLITICS AND REDEMPTION: THOMAS PYNCHON AND THE IDEA OF ENTROPY

> Paranoia substitutes a rigorous (though false) order for chaos, and at the same time dispels the sense of individual insignificance by making the paranoid the focus of all he [or she] sees going on about him [or her] -- a natural response to the confusion of modern life.
>
> -Henrik Hertzberg and David McClelland[1]

> We have here an instructive illustration of the established fact that to the untrained eye randomness appears as regularity or tendency to cluster.
>
> -William Feller[2]

The study of the work of Thomas Pynchon constitutes a fitting reprise to our look at that of Henry Adams, for one useful way of interpreting Pynchon's work is to see it as being, like Adams', grounded in the idea of entropy used as metaphor, and Pynchon, like Adams before him, is concerned with the human effort to make the phenomena of the world intelligible by discerning therein pattern, regularity, and hence meaning. Pynchon rarely scruples to hide his literary tracks, and in "Entropy," one of his early short stories (published in 1960, a year after his graduation from Cornell), he makes his debt to Henry Adams obvious. The reference is explicit: "Henry Adams, three generations before his own, had stared aghast at Power. Callisto found himself now in much the same state over thermodynamics, the inner life of that power."[3] The connection is reinforced when Callisto goes on to dictate, in the third person, his Adams-like memoirs to his girlfriend:

> 'As a young man...Callisto had learned a mnemonic device for remembering the laws of thermodynamics: you can't win, things are going to get worse before they get any better, who says they're going to get better. At the age of 54, confronted with Gibbs' notion of the universe, he suddenly realized that undergraduate cant had been oracle, after all. ...He found in entropy or the measure of disorganization for a closed system an adequate metaphor to apply to certain phenomena in his own world. He saw, for example, the younger generation responding to Madison Avenue with the same spleen his own had once reserved for Wall Street: and in American "consumerism" discovered a similar tendency from the least to the most probable, from differentiation to sameness, from ordered individuality to a kind of chaos. He found himself, in short, restating Gibbs' prediction in social terms, and envisioned a heat-death for his culture in which ideas, like heat-energy, would no longer be transferred, since each point in it would ultimately have the same quantity of energy; and intellectual motion would, accordingly, cease.'[4]

Although Pynchon himself has since denigrated this story,[5] we can find in it the beginning of a fascination with the idea of entropy, a fascination that remained with him through his three novels, and the beginning of his effort to work through the same problem with which Adams had grappled with earlier: the problem of discerning order in the apparent chaos of history, the effort to make sense of the world. It is a problem that is central to Pynchon's novels, and one which his readers, no less than his characters, come to confront.

Pynchon's readers must confront the problem of discovering order in a chaotic universe because the universe of Pynchon's fiction is dense and many-textured; there is no one single reading of his work that occupies a privileged position. Papers could be -- and have been -- written about Pynchon's use of song;[6] about his use of chemistry, probability, mathematics, and thermodynamics in his novels and stories;[7] about his presentation of women characters, his treatment of Anarchists and Marxists, his willingness to test (and to violate) the boundaries of taste and propriety;[8] about the scientific imagery in his works;[9] about his relationship to Max Weber, Henry Adams, Marshall McLuhan, Mircea Eliade, Carl Jung, Ludwig Wittgenstein;[10] about his "paranoid history", his "calculus of transformation," his fascinations with "Mass Man and Modernism," "Caries and Cabals," the Occult, Mandala imagery, with ambiguity.[11] Such analyses of Pynchon's work are the product of literary criticism, and some part of their number and variety can be explained by the growth of literary criticism as a modern, and academic, industry. As any other industry, it requires raw material: hordes of professors and graduate students descend on new literary works, digesting them, analyzing them, relating their elements to those of other works or to their own arcane systems of exposition and analysis. Given the premium placed on publishing in the Academy, it is no wonder that Pynchon's works have been approached from so many different angles; one slim wedge of insight is all that is needed for an article, and hence an easier time of it at a tenure review.

And yet, only part of this profusion of critical attention to the work of Thomas Pynchon can be explained by the dynamics of the industry itself. Pynchon's works are remarkably susceptible to this sort of reading -- though Pynchon himself apparently does not approve: one of the conditions of his contract with his publisher is reported to be a prohibition on their publishing any book that contains any such analysis of his work.[12] His work defies summary -- whether of plot, of stylistic devices, conventions, and structure, or of imagery, of theme, of character development. The only complete statement of the work is the work itself -- a circumstance that leads many of his exegetes (who have usually, one senses, been drawn to his work as partisans of its aesthetic and political agenda) to finish with a resounding call to read the work itself.[13] And yet the work requires exegesis; as the above list of article and chapter subjects begins to indicate, his work is nearly unprecedented in the number of other texts that can be -- fairly must be -- brought to bear upon it. "One has to know an awful lot to learn what it is that Pynchon feels -- not only about Zap comics and horror movies, but about physics, mathematics, Puritan theology, and a library of literature that he uses or parodies or both."[14] Pynchon's major novel, Gravity's Rainbow, is rife with recondite allusions, hidden puns,[15] enticing clues to buried meanings, and textual fingers that point to works beyond the text as a possible source of further meaning. Those texts serve to gloss his work, just as his work glosses them -- and the conventions of textual exegesis as well. Pynchon celebrates, and seems to be writing for, the preterite, the passed-over, the powerless, the schlmiels and boozy sailors among us; and yet his work is nearly inaccessible to one not trained in literary hermeneutics, literary detective work, and the conventions of "meta-fiction". What presents itself to the unsophisticated eye as an arbitary or random element in his work often yields, upon analysis, a purposefully open-ended sense of connection, of "regularity or tendency to cluster."

The fact that Pynchon's work encourages a sort of literary mining, while none-too-subtly mocking that activity and throwing serious doubt upon its validity, accounts for the aplogetic tone that some of his exegetes take: "As editors of this volume," Levine and Leverenz write, "we know there's not much we can do to please him. Wherever you are, Thomas Pynchon, we apologize."[16] But Pynchon's point in creating dense fictions is not to extract these apologia, nor simply to challenge the grounds upon which any criticism of his work must be founded. Nor is his peculiar relationship to his audience of exegetes to be explained as the product of a desire to show off to an audience he knows exists, and dislikes. Nor is it the result of a solipsistic game played by an author with entirely too much information at hand.[17] The density of his work -- its richness, its profusion of almanac-like information -- seems intended to demonstrate the truth of Henry Adams' dictum that "All opinion founded on fact must be error, because the facts can never be complete, and their relations must be infinite."[18] One effect of this density, of this near-infinity of possible relations, is that the reader is propelled into confronting the same order of problems that face Pynchon's heroes and heroines: readers are "enlisted in the same pattern-seeking which lures and afflicts the characters,"[19] they are asked not so much to read a novel but to "read <u>among</u> the various possible interpretations of the book,"[20] they are "seduce[d]... into grail-hunting activities which [Pynchon] then parodies."[21] How this happens, what relationship this quality of his fiction bears to his repeated and extended use of entropy as metaphor, and what, finally, the two together suggest about the essentially political quest for order is the particular "wedge of insight" that will animate this chapter.

Each of Pynchon's three novels revolves around the question of paranoia. The main character of Pynchon's first novel, V., is a young man prone to discovering ominous "cabals" behind the random "caries" of his world;[22] in Pynchon's second novel, the heroine, Oedipa Maas, wonders whether the events she experiences are connected by some thread other than the thread of her own need to find continuity and order in her existence, whether in fact she is in "the orbiting ecstasy of a true paranoia" or whether the Tristero -- the centuries-old private mail service that has gone underground, and which seems to be inextricably enmeshed in the affairs of the estate she has been appointed to execute -- really exists; and in Gravity's Rainbow, "we are presented not with a plot of interwoven fates, but with overlapping case histories of private manias, each character locked within his or her own conspiratorial fantasy."[23] The problem of sorting out paranoid delusion from rational perception of connection becomes the reader's own problem, not through identification with characters (the characters are, to say the least, difficult to identify with), but through the way Pynchon's mature works are constructed, through their density of signification and apparent infinity of possible connection. Those connections do not occur solely within the text, but reach out to encompass all manner of background information that the reader may -- or may not -- have available.

To give but one example: in Pynchon's second novel, _The Crying of Lot 49_ (hereinafter cited simply as _Lot 49_), Oedipa Maas runs into a character named Thoth, who can offer a clue to the riddle of the Tristero. Though Thoth is found in a nursing home, watching old Porky Pig cartoons, the reader well-grounded in comparative religion or mythology might suspect that he is a stand-in for Thoth, the Egyptian god of letters and learning, named as "scribe of the gods" in Budge's compilation of _The Egyptian Book of the Dead_.[24] The same sophisticated reader might know that according to _The Tibetan Book of the Dead_ (which, like its Egyptian counterpart, is meant as a guide for the dead during the period of transition to the afterlife), the soul spends forty-nine days in the Bardo, the intermediate state between death and rebirth.[25] The reader might come to find in the title of the book another clue to a transcendent meaning; perhaps the journeys re-croded therein are the journeys of its heroine, a seeker, on her way from a sort of walking death to a rebirth. That Thoth is the Egyptian god of letters resonates with other themes in the book -- the ambiguous letters W.A.S.T.E. that Oedipa keeps running across could merely be signs on refuse containers, or they could be the intials of the motto, "We Await Silent Tristero's Empire", an empire through which, perhaps, "X number of Americans are truly communicating whilst reserving their lies, recitations of routine, arid betrayals of spiritual poverty, for the official government delivery system." (Lot 49, p. 128.) The pun on "letters" is obvious enough; but letters taken together form words -- and perhaps letters sent through the Tristero are Letters, individual fragments of the Word, as in the logos, the organizing principle that Oedipa, as a modern, has lost: "...she wondered if the gemlike clues were only some kind of compensation. To make up for her having lost the direct, the epileptic Word, the cry that might abolish the night." (p. 87)[26] But then, thinking we have deciphered the number in the title, what are we to make of all the lunar imagery in the novel, and the fact -- nowhere presented in the text (but then, as one character asks, "Why...is everybody so interested in texts?" p. 55) -- that the moon is one forty-ninth the volume of the earth? Pynchon suggests that the Pacific Ocean is "the hole left by the moon's tearing free and monument to her exile" (p. 37), which could draw the Pacific Ocean -- for Pynchon, not only etymologically a symbol of peace, but also a symbol of redemption[27] -- into the host of possible meanings of the number given in the title. The ocean is fecundity, permanence, "pacific", redemption, a monument to exile, to freedom; each of these may, with some effort at connection on the part of the reader, be made to resonate with the forty-nine days of Oedipa's "Bardo" existence, her journey into the great ocean of meaning-in-modern-America.

Which -- or how many -- of these meanings are intended? The question, of course, does not admit of an answer; but to ask it does point up the way readers of Pynchon's texts are led to confront a proliferation of meanings that reach beyond the text, and are led to speculate on whether those meanings are coincidence or some part of an authorially-engineered "plot".[28] In so speculating the reader begins to flirt with the paranoid systems the characters are drawn toward.

Other examples of such ambiguities abound in Pynchon's work; his history of the Thurn and Taxis postal system in Lot 49 is, in most of its particulars, essentially correct[29], for all its improbability; so also with the story of the Ojibwa "Windago", the crazed, destructive, cannabilistic spirit, which is an important plot element in Pynchon's second published short story[30]; so also with the malevolent connections between Shell Oil, I.G. Farben, and the Nazis, which connections form part of the paranoid "plot" that Tyrone Slothrop confronts in Gravity's Rainbow. All of Pynchon's plots thread through realms of coherent fantasy grounded in improbable fact; unlike other authors whose works offer compendia of factual material, Pynchon chooses his facts not to reinforce a sense of realism but to violate our sense of the real[31] -- the better to force us, as readers, to recognize the essential ambiguities in our "real" worlds, and our role in constructing our meanings within it.

As both Pynchon's readers and characters are drawn into quests for meaning, they are led to inhabit metaphoric ground that Pynchon has created through his use of the idea of entropy. Entropy serves as a controlling metaphor in all three of Pynchon's novels and in one of his short stories. Although paranoid plots and thermodynamics are present in each of the novels, the connection between them is most obvious in his shortest novel, Lot 49. There, Oedipa specifically recognizes herself to be a Maxwellian Demon, resisting the tendency of her world toward disorder. The connection is first made in a near-literal way, in her encounter with the eccentric inventor John Nefastis, who has her sit before his machine, a Maxwellian container with two chambers. She is to meditate on a picture of Maxwell, and attempt to commune with the sorting Demon inside the container in an effort to move the piston that separates the two chambers. If she can do so, she will, of course, accomplish physical work without any expenditure of (physical) energy. (pp. 76-79). In communing with the demon, she is trying to help it perform its task -- she is trying to become, literally, a Maxwellian demon, creating a difference in average kinetic energy in molecular subsystems where there had been none, before.

This introduction of the concept of entropy allows Pynchon to work the idea for its metaphoric meanings. In the major metaphor of the novel, Oedipa is likened to a sorting demon for her role in sifting through the estate of her ex-lover, millionaire practical joker Pierce Inverarity. Inverarity's corporate interests spanned every facet of American life, and are (we learn in the first sentence of the book) "numerous and tangled enough to make the job of sorting it all out more than honorary." (p. 1) When Oedipa receives an explanation of Maxwell's demon from another character, a few pages before her experience with the Nefastis machine, she offers Szilard's objection in these words: "Sorting isn't work?"

The references throughout the novel to her efforts to "sort through" Inverarity's affairs, the clues to Tristero she falls upon, and her own past make the parallel clear: Oedipa is a sorting demon, creating order from the chaos of possible connection, possible significance. In doing so she flirts with paranoia: "Shall I project a world?" she asks herself. (p. 59) The paranoia is manifest as a neat symmetry of either-or choices, choices from which any middle term, any ambiguity, has been excluded. (pp. 136-7)[32]

In her inability to see, at first, beyond these paired dualisms, she is like the character Pointsman from Gravity's Rainbow; he, a Pavlovian behaviorist, strives for the clarity of binary choices, the unambiguous either-or. He stands in contrast to Roger Mexico, whose science of probability is a lietmotif in the novel and one of the few paths presented therein by which to establish a sane (i.e. non-paranoid) sense of relation, connection, and meaning. (To accomplish this, Mexico must resist the urge he feels to become an "Anti-Pointsman" -- which is, perhaps, what They want him to be....) Oedipa eventually plays Mexico to her own Pointsman, for the logical pairings she sees before her have their symmetry destroyed by the power of reason and her empathy for the downtrodden and disaffected who seem to be using the Tristero to communicate:

> Ones and zeroes. So did the couples [of choices] arrange themselves....Another mode of meaning behind the obvious, or none. Either Oedipa in the orbiting ecstasy of a true paranoia, or a real Tristero. For there either was some Tristero beyond the appearance of the legacy of America, or there was just America and if there was just America then it seemed the only way she could continue, and manage to be at all relevant to it, was as an alien, unfurrowed, assumed full circle into some paranoia. (p. 136-7)

This passage evokes at least two previous metaphoric significations established earlier in the novel. The "Legacy of America" is indicated, for Oedipa, by the legacy of Pierce Inverarity. (p. 135) Oedipa variously wonders if Inverarity's legacy is his attempt to "leave an organized something behind after his own annihilation" so that as executrix it would be her duty "to bestow life on what had persisted" -- which resonates not only with the entropy metaphor at the heart of the novel (life is anti-entropic, in the sense that it organizes matter through use of energy; death is entropy catching up with biological systems) but with the imagery through which Oedipa conceives her paranoia, the paranoia that gives birth to her belief in the necessity of the Tristero: "Your gynecologist has no test for what whe was pregnant with." (p. 131.) She also wonders whether Inverarity has tried to survive death, tried to (as he used to tell her) "keep it bouncing" (p. 134) "as a paranoia; as a pure conspiracy against someone he loved" (p. 134), or whether the Tristero exists and Inverarity bought into it and "coded it into his will" just enough so that he'd be sure she found it. "Alien, unfurrowed" evokes an earlier passage in which Oedipa, pieta-like, cradles a trembling, drunken old sailor in her arms, a sailor who suffers from the DTs:

> Behind the initials was a metaphor, a delirium tremens, a trembling unfurrowing of the mind's plowshare....Oedipa did not know where she was. Trembling, unfurrowed, she slipped sidewise, screeching back across grooves of years, to hear again the earnest, high voice...[of a college lover complaining about] his freshman calculus: 'dt', God help this old tatooed man, meant also a time differential, a vanishingly small instant in which change had to be confronted at last for what it was, where it could no longer disguise itself as something

> innocuous like an average rate; where velocity dwelled in the projectile though the projectile be frozen in midflight, where death dwelled in the cell though the cell be looked in on at its most quick. (pp. 95-6)

That we are so often thrown back, in Pynchon's work, on previous reading -- and forward, into images and connections yet to come -- suggests that the demon is not the sole term from among the "system of associated commonplaces" belonging to the idea of entropy to be used by Pynchon. Time, too, is part of the associative ground of the entropy metaphor that figures prominently in Pynchon's novels. In Lot 49, we have a movie whose reels are projected out of sequence, denying the continuity, the uni-directionality of time. Oedipa loses, in her confusion, her ability to remember when she learned what about the existence of the Tristero. The clues, the hidden meanings, the relations, are all present and apparent to her at once, with no logical or temporal sequence discernible within them; she is, briefly, suspended outside of time (or in her own primary processes of mind). It is a condition also represented in Gravity's Rainbow, most obviously by the "Other Side" -- the realm of the dead, the realm of pure spirit -- which Slothrop's unit is exploring, through studies in parapsychology and paranormal phenomena, for its possible contribution to the war effort. As the narrator tells us, "No serial time over there; events are all there in the same eternal moment and so certain messages don't 'make sense' back here: they lack historical structure, they sound fanciful, or insane" (p. 727). This is a state that Pynchon enjoys as the narrator of the novel -- all of its events are present to him, as its creator -- and it is one that he asks his readers to enter into, in their search for meaning in the work: in the effort to connect up the proliferation of metaphoric significations, a reader must "screech back across the grooves" of pages past, unfurrowed from slavish fealty to the sequence of the text. Gravity's Rainbow goes farther in its stylistic efforts to transcend the limits of historical narration: like its main character, the book dis-integrates at the end. Pynchon gives up any pretext to narration and temporal sequence, presenting instead a series of seemingly discontinuous short tales that skip about in time and location. And prior to that point, the narrative structure of the work has not been the temporal, historical sequence of events-in-time that we are accustomed to; the narrative is propelled on its erratic course by entering into, in succession, the manias of its characters, each with its own history and characteristic slant on events, each one acting as a gravitational field that catches the narrative for a moment and then propels it into the next. There is considerable understatement in Schaub's judgment that "The absence of 'historical structure'...makes tremendous demands upon the reader" for integration.[33] Some of the challenge is sheer act of memory: events connected in meaning and plot, events succeeding each other in time, are widely separated in the novel, and "mnemonic structures are almost wholly absent."[34] And at the heart of one of the plots of Gravity's Rainbow is an apparent violation of time, an apparent reversal of the relationship between simulus and response, cause and effect: Tyrone Slothrop, having been "conditioned" as an infant to become aroused at the smell of Impolex G, experiences an erection at the approach of the V-2 rocket, whose nose cone is made out of the plastic -- but Slothrop's responses come several days or hours before the arrival of the rocket.[35] This parodic denial of time is not only evidence of the novel's grounding in thermodynamics as a controlling metaphor, it also suggests that Slothrop, among the living, already participates in the "Other Side" somehow, through the "trembling unfurrowing" of his libidinal plowshare.

The lack of historical structure, the lack of a privileged point of view by which to measure relation, the lack of clear-cut causal relation[36] -- all of these contribute to making the novel a dense, forbidding, and exhilarating work of art. Enormous emphasis is placed on the imagery and metaphor in the work as devices for unifying and integrating the text itself; and, dominating all other imagery and metaphor in the work is the gravitational field of the entropy metaphor. In Gravity's Rainbow Pynchon projects a world-in-text, a Word, grounded in the statistical chaos, the ambiguity, the flux of probabilities of the second law of thermodynamics; and that world is a dark mirror to our own.

There is yet a third order of metaphoric signification of entropy, in addition to sorting demons and temporal sequence, in Pynchon's work: the network of associations that the idea of entropy has picked up in the field of information theory and communication. In "Entropy," we find the following dialogue:

> "Tell a girl 'I love you'. No trouble with two thirds of that, it's a closed circuit. Just you and she. But that nasty four-letter word in the middle, <u>that's</u> the one you have to look out for. Ambiguity. Redundance. Irrelevance, even. Leakage. All this is noise. Noise screws up your signal, makes for disorganization in the circuit."
>
> Meatball shuffled around. "Well, now, Saul," he muttered, "you're sort of, I don't know, expecting a lot from people. I mean, you know. What it is is, most of the things we say, I guess, are mostly just noise."
>
> "Ha! Half of what you just said, for example."[37]

But the story also offers us the spectacle of a group of jazz musicians playing a piece that is beyond the entropic depradations of noise in the channel; the Duke di Angelis quartet is "going through the motions of having a session, only without instruments"; they are <u>thinking</u> the song, "roots, line, everything." This is an image that Pynchon returns to several times in his work -- not only in his fiction (where Oedipa encounters a convention of deaf-mutes and is swept into their ballroom, where they -- and she -- dance to "some unthinkable order of music, many rhythms, all keys at once, a choreography in which each couple meshed easy, predestined. Something they all heard with an extra sense atrophied in herself," p. 97), but in his one published piece of journalism, as well. In an essay on the mood in Watts a year after the riots of 1965, Pynchon suggests that "violence may be an attempt to communicate, or to be who you really are," and then describes the riots in terms that evoke the deaf-mute convention and the jazz musicians:

> Others remember it in terms of music; through much of the rioting seemed to run, they say, a remarkable empathy, or whatever it is that jazz musicians feel on certain nights; everybody knowing what to do and when to do it without needing a word or a signal: "you could go up to anybody,

> the cats could be in the middle of burning down a store or something, but they'd tell you, explain very calm, just what they were doing, what they were going to do next. And that's what they'd do; man, nobody had to give orders."[38]

Pynchon obviously had yet to develop an ear for dialect -- a lack he bemoans in one of his few other non-fiction appearances in print.[39] Our knowledge of his work, and of the fact that Lot 49 was in process when this was written, might make us suspect that there is more of the novelist that the journalist in the quotation in this passage. Besides finding in this passage a tendency to romanticize violence committed by a disempowered group, we can see here the roots of the myth of a subversive sub- or counter-culture that animates Lot 49.

Paradoxically, that counterculture is the product of both an entropic and an anti-entropic dynamic. As Mendelson suggests, in Lot 49 Pynchon reverses the metaphoric signification he had attached to the idea of entropy in his first novel, V.. He shifted from a reliance on the thermodynamic significations of entropy (decline, heat death, chaos) to those found in information theory (where entropy is a measure of possibility). Along with an increase in (informational) entropy comes increased possibility, and one possibility realized in the novel is that the tendency of American culture toward a listless homgeneity ("And how had it ever happened here," Oedipa wonders, "with the chances once so good for diversity?" p. 136) will be reversed in the birth of a new counter-culture. (Pynchon is not using entropy literally here; as a thermodynamic law entropy tells us "you can't get something for nothing," and the price of increased capacity in an information channel is use of more energy).

Oedipa assumes herself "full circle into some paranoia" by recognizing the necessity of inventing that counter-culture: her experience makes sense only if Tristero exists. If it does exist, then the clues she has found have meaning, beyond her own ability to imagine them as connected. If Tristero doesn't exist, then it is necessary to invent it, necessary for there to be more meaning in "the legacy of America" than the brutal stupidity of Tupperware parties (p. 1) and lonely, meaningless death (p. 96), necessary for life and culture to be more complex, more ambiguous, more meaningful than the official, Pointsman-esque "They system" would have it. It is a necessity because the mind can imagine it, and in the act of imagining create it; it is a necessity because, as Oedipa's husband tells her,

> "When those kids sing about 'she loves you', yeah well, you know, she does, she's any number of people, all over the world, back through time, different colors, sizes, ages, shapes, distances from death, but she loves. And the 'you' is everybody."[40]

In the confines of the novel, these are the sentimental musings of a drug-ravaged mind; but Pynchon is not above putting authorial insight into the unlikeliest of mouths. Each character, even the ones we find most repulsive, offers a piece of the truth.[41]

Others have noted that Lot 49 is a subversive novel in its transcendence of either-or logic, a transcendence that is effected in such a way as to draw the reader unambiguously into the complexities and ambiguities it presents; "For, by the time any one of us finishes the novel, we are all members of Tristero."[42] But in addition to the myth of the Tristero itself, there is another subversive element in the novel, to be found in the way that Oedipa comes to her "conclusions", her accomodation with the legacy of America and its manifestation in the back streets, vacant lots, freeways, housing developments, and corporate headquarters of the American Dream. Oedipa achieves her new insight, she breaks down the either-or logic and participates in an "anarchistic miracle"[43] by engaging in a community of inquiry. It is a community that she creates in her movement through the novel. It is centered on her and her need for information about the Tristero, but her ultimate resolution of the paradox of the existence of the Tristero depends not on her mere use of various individuals for confirmation of clues, signs, and connections, but on her ability to identify empathetically with (what the closing song of Gravity's Rainbow will call) every "poor Pret'rite one." Hers is not the isolated quest of the vision seeker, but the social enterprise of the seeker of political meaning, and her discovery of that meaning both depends on and creates a community of Preterite and her identification with it.[44] That community is broadened in Gravity's Rainbow to include even the Elect: as Tyrone Slothrop's Puritan ancestor knew (p. 647), the Elect depend upon the existence of the Preterite to set them apart, to define them, so that ultimately, in the transcendent union of paranoid visions, the neat either-or distinction between Elect and Preterite is dissolved.

Gravity's Rainbow, Pynchon's major work and the one in which entropy suffuses both form and content, has been called "encyclopedic" by at least two critics -- one in passing[45] and one in the essay upon which I relied in setting out, in the introductory chapter, thoughts on the relationship between epic, encyclopedic literature and epic political philosophy. Edward Mendelson finds that Gravity's Rainbow is the encyclopedic work of a "new international culture, created by the technologies of instant communication and the economy of world markets," and that the appearance of the novel marks that culture's awareness of its own distinct existence.[46] This reading is supportable by the evidence of the text; to characters in the novel, to the narrator of the novel himself, The Firm -- the apotheosized military-industrial-governmental complex that "Gen. D. D. Eisenhower, closet preterite and honorary paranoid," warned us about -- takes on the appearance of a de facto world government, ruling according to technological and economic necessity. The novel can be read as tracing out the arc of development -- the Gravity's Rainbow -- of a modern dynamic: the development of a world federated, corporative "state" that some political scientists have envisioned as the culmination of Liberal-Capitalist political principles.[47] Interestingly, Pynchon locates the origins of this world-cartel and de facto government-by-transnational-relations in the politically chaotic geography of postwar Germany, after the surrender but before separate occupation zones have been set up. The largest portion of Gravity's Rainbow is set "In the Zone", a "stateless" realm of flux, a plasmatic territory in which all formal and institutional political relations are suspended. It is a realm of anarchy, of possibility. The Firm, it seems, has engineered the War to create this blank political slate in order to solve the "real crisis":

> This War was never political at all, the politics was all theater, all just to keep the people distracted...secretly it was being dictated instead by the needs of technology... by a conspiracy between human beings and techniques [...]. The real crises were crises of allocation and priority, not among firms -- it was only staged to look that way -- but among the different Technologies, Plastics, Electronics, Aircraft, and their needs which are understood only by the ruling elite...(p. 607; my elipsis in brackets; the rest, Pynchon's).

This arc of development, like the Gravity's Rainbow of the rocket that takes off on the first page and descends on the last, reaches the reader's "present" from the political relations of the past; in World War II, with its interlocking, international cartels, its official state policies of paranoia (Germany and the Jews, America and the Nisei, America and Russia in the Cold War), its growth and development of technologies of all kinds, including those of political "persuasion", propaganda, and civilian regimentation, Pynchon finds the root of the modern malaise. It is a malaise unequivocally grounded in the law of entropy. For if, as the character Enzian (whose paranoid musings are quoted above) discovers, the world is ruled by one big Firm, the Firm itself is ruled by Technology, and Technology is constrained by the dictates of the matter and energy it manipulates -- and behind those constraints lurks the shadowy second law. Pynchon has laid bare what is delicately avoided by the new Physiocrats, such as Georgescu-Roegen, whose work was discussed in the previous chapter: accept the premisses of consumer culture, accept the domination of the earth by humans through industrial culture, and the laws of thermodynamics will prove to be as effective a tyranny as the world has ever seen.

This grounding of a political order in the cosmological vision of thermodynamics is the source of the novel's darkness of vision. What had been, in Lot 49, a benign, even redemptive conspiracy -- the Tristero, a lark, perhaps a prank engineered by Inverarity as one final, death-defying practical joke, with only a shade or two of ominous meaning behind it -- becomes, in Gravity's Rainbow, "The Firm", "I.G. Raketen", an obscure and malevolent Force. It seems, then, that in his major work, in his encyclopedic novel grounded in the entropy metaphor, Pynchon is offering us no hope.

And yet, there is a deeper characteristic of modern culture that the novel serves to apotheosize: the irreversible development of an epistemology grounded in social, and hence political, relation. In the politically-charged territory of the Zone, all political organization exists as potential; the question is, whose "We system" will prevail and define the political organizaton of the turf. It is, sometimes, an arena in which the only salvation from paranoia is the successful exercise of political power; the successful "We system" defines itself as truth, and all other "we systems" as paranoid aberration. ("'They systems' [...] are what They and Their hired psychiatrists call 'delusional systems'," Pirate Prentice explains to Roger Mexico. "Needless to say, 'delusions' are always officially defined," p. 743.) The connection here between paranoia, politics, and epistemology is also rooted in Pynchon's use of the entropy metaphor as the foundation for his vision: in the chaos of signification, meaning ramifies, connections proliferate, and "to be intelligent" is almost -- but not quite -- synonymous with "to be paranoid". That is, Pynchon shows us the potential danger of a culture in which individuals are left to construe their own, individual meaning in an ambiguous world -- a world of probabilities, a world of statistical thermodynamics rather than mechanical certainty -- and that danger is solipsistic paranoia. The only escape from such paranoia is through connection to others in a "we system" capable of tolerating ambiguity; without connection to others, or in a Manichean "we system", the product of the conscious attempt to construe order in the world is always and everywhere paranoia.

As critic Scott Sanders has noted, Richard Hofstadter's essay on "The Paranoid Style in American Politics" provides an interesting gloss on the text of Gravity's Rainbow.[48] The style that Hofstadter describes is "far more coherent than the real world, since it leaves no room for mistakes, failures, or ambiguity" -- or, we can add, chance.[49] It is a "political pathology" marked by apocalypticism, "exaggeration, suspiciousness, conspiratorial fantasy," and a willingness to see an enemy -- whose actions threaten "the birth and death of whole worlds, whole political orders, whole systems of human values" -- as a "perfect model of malice," as "sinister, ubiquitous," nearly omnipotent, "a free, active, demonic agent" capable of deflecting the course of history.[50] The correspondence between this diagnosis and the belief systems that Pynchon's characters orbit around is so exact that we might, along with Sanders, suspect more than an extra-textual coincidence. The passage on Paranoid Systems of History in Gravity's Rainbow (p. 277) seems especially to owe a debt to Hofstadter's essay, which he published the year that Pynchon began his decade of work on the novel. But we need not conclude, along with Sanders, that Pynchon is advocating paranoid belief systems in his work.[51] To do so would be to miss entirely the pedagogic value of the "Proverbs for Paranoids" scattered through parts of the novel,[52] and to misconstrue the central tension of the novel, the tension in which Pynchon locates his characters (and by extension his readers), the tension they (and we) are called upon to straddle: that between paranoia and anti-paranoia.

> If there is something comforting -- religious, if you want -- about paranoia, there is still also anti-paranoia, where nothing is connected to anything, a condition that not many of us can bear for long. Well right now Slothrop feels himself sliding onto the anti-paranoid part of his cycle, feels the whole city around him [...] going uncentered as he is ....
> Either They have put him here for a reason, or he's just here. He isn't sure that he wouldn't, actually, rather have that reason....(p. 506)[53]

So far is Pynchon from advocating paranoid belief systems that Slothrop, who ultimately succumbs to paranoia (and not without cause; he actually is being chased by several groups), dissolves at the end of the book -- even his friends fail to hold him together, even as "concept", that non-corporeal entity immune to entropy. This is the fate of paranoids: to be at the mercy of external forces and events, in a kind of self-fulfilling prophecy, so that the diversity of life they encounter does not enrich their lives, but dissolves it. Complete paranoia, or any other system of automatic response, is disempowering; in it, one yields up the power to construe meaning, to create, to create one's self, by giving it to external agents. Slothrop's dissolution of self is a result of that disempowerment.

But, Pynchon does not believe that Slothrop's fate must necessarily be our own. There is a redemptive vision in even this bleak novel; we are not simply given the cold stone of paranoia to suck as consolation for the social, political, and ontological dislocations of the modern world. One point of stable meaning in the novel is its "insistence upon the humility of the Preterite lost in...a world where the stability of simple distinctions is absent," as one critic puts it;[54] there is a tremendous communal impulse behind the intimacy of Pynchon's voice, a community created not solely out of our common plight as incipient paranoids or potential victims of the rocket that, having taken off on the first page, makes its descent 887 pages, and some 30 years, later. "Listen to this mock-angel singing, let your communion be at least in listening, even if they are not spokesman for your exact hopes," Pynchon encourages us (p. 157). In the context from which this quotation is drawn, the mock angel is only most obviously the rocket; the cynicism in Pynchon's voice given by that reading is moderated by the alternatives (for in this, as in most aspects of the novel, qualities are balanced by their opposites, co-existing as points on a complex mandala-nexus of paired extremes). "There's nothing so loathsome as a sentimental surrealist," the narrator warns (p. 811) -- or, by implication, a surreal cynic. The mock angel singing is not only the rocket, but Pynchon himself, singing the myth he hopes will redeem us. Thus, in construing Gravity's Rainbow as suggesting that paranoia is our only choice, Sanders misses the grounds Pynchon offers his readers for the construction of non-psychotic "we systems": the common human appreciation of art, a sharing in song, myth, story, -- whatever -- the meanings about human experience that humans have created.

Art, as a network of shared meanings, rescues us from the further reaches of paranoia and anti-paranoia; it manages to be political -- a shared sense of meaning, which brings order to the chaos of possible signification, must always be so -- yet participatory, powerful yet non-coercive, esemplastic yet not paranoid. And unlike language, which is, for Pynchon, most assuredly political[55] but severely limited when constrained to literal uses, art can communicate a broader range of meaning without suffering the entropic decay of noise in the channel. For Pynchon, song -- and by extension other forms of art -- is the "magic cape" sheltering us from "the terrible politics of the Grail." (p. 817)

The art is, to be sure, Pynchon's own, and we may detect a note of megalomania in his willingness to extend to us his vision as our organizing principle. At one point, a character in Gravity's Rainbow speaks words that Pynchon might well have spoken to his readers:

> We define each other. Elite and preterite, we move through a cosmic design of darkness and light, and in all humility, I am one of the very few who can comprehend it in toto. Consider honestly therefore [...] which side you would rather be on...(p. 577).

God-like, Pynchon stands outside of his text -- the text that holds our world -- and holds its complex of meanings together; he stands outside its confusing time scheme and narrative structure; he offers us that text, his logos, his Word. But to ascribe to Pynchon this sort of megalomania is to deny the genuine humility behind the knowing voice, to miss completely his identification with the reader (and his plea that the reader identify with him), and to ignore the way that megalomania -- a position he flirts with -- is the antithesis of humble preterition, a position he also embraces. Pynchon does not seek disciples; he just wants to share his art with the world. His avoidance of the modern cult of the author, his famed secretiveness, his aversion to publicity, are not an effort to create yet another continuity between his texts and our world; they aren't another authorial plot to provoke our curiosity and our search for clues, as some would have it.[56] Given what he has written, his absence from public life is simply a matter of common decency, and of consistency with his political message.

The myth that Pynchon offers us tells us, in both its form and its content, that we occupy the ambiguous middle ground of a complex nexus of opposites, neither fully paranoid nor anti-paranoid, neither preterite nor elect, capable of borrowing our understanding from others or of ignoring the possibilities for meaning altogether in a brute, non-conscious existence, but fully at home in neither extreme. His main characters "move from a condition of lethargy in which 'meaning' is not even an issue, to a pursuit of meaning which veers into paranoia, and whose virtue [ultimately] lies not so much in anything such seeking might accomplish as in the moral alertness it induces."[57] As with Pynchon's characters, so, he hopes, with his readers. We may never achieve the "stelliferous Meaning," the grail his characters pursue but never quite achieve; we may never recover the "epileptic Word". But Pynchon holds out to us the possibility that through the social experience of art, we may yet accumulate enough of the Letters to make out the shape of the Word.

Gravity's Rainbow, then, offers us an encyclopedic, apotheosizing vision of our culture that is at once redemptive and grounded in the idea of entropy used as a root, organizing metaphor. In this, Pynchon constitutes something of an anomoly: one could not describe the work of Brooks Adams, Henry Adams, or Nicholas Georgescu-Roegen as offering much in the way of hope for the future. Only Wilhelm Ostwald conjoined a grounding in thermodynamics with an optimistic view of the human future. And yet, Pynchon is no optimist, and he came to a vision diametrically opposite that of Ostwald's; one senses that Pynchon would think Ostwald a fool or a man lacking the imagination to be a paranoid for his sanguine acceptance of "The Firm," the international corporative organization designed to meet the challenge of the second law. More difficult to see, and therefore more interesting to consider, are the grounds for difference between Henry Adams and Thomas Pynchon, the two "poets" we have examined, the two thinkers who used the idea of entropy consciously, not as literal, scientific truth but as a suggestive metaphor. Adams, we noted, scarcely saw the importance of the social and political foundations of knowledge, the foundations that Pynchon has assumed in grounding his novels on the metaphoric significations of entropy. Perhaps because of this, Adams exercised his voice alone, writing in the third person, ruminating in the ashes of a nineteenth-century vision about the nature of the world to come, while Pynchon described the world as it has become, warning us about the need for (and helping to create in the warning of it) the only community that could be both his audience and his source of hope. That both authors were firmly grounded in the idea of entropy as an organizing metaphor indicates that the metaphor is capable of diverse application; it, like the other root metaphors, is capable of supporting different schools of thought.

Pynchon, perhaps more than any other individual, has defined for a generation the system of associated commonplaces that attach to the idea of entropy. His novels were, and continue to be, enormously popular; even the forbidding *Gravity's Rainbow* made an appearance on the best seller lists in the year of its issue. But Pynchon not only defined the system of associated commonplaces for the central metaphor of his work, he *redefined* it. Within his work entropy stands not as a symbol of inevitable decline, or not *only* for such decline, but also as the symbol of rebirth, renewal, and redemption. His work is peculiar in that it is both noetic and metaphoric, self-referential but not mannered and indulgent. He shows us the conjuror's tricks by which he creates his art, and yet we are not on that account led to dismiss it. In this we may find the continuing value of his art: as against the vision of order embodied by The Firm, Pynchon proposes a subtler vision of order rooted in the noetic appreciation of metaphor. That is, as a response to the dilemma that Henry Adams faced (the dilemma embodied in Adams' rational recognition of the need for an animating mythos) Pynchon offers us a resolution in the form of a narrative that embodies a grand, almost mythic metaphoric scheme, is conscious of that grounding and aware of its limits, but succeeds in ordering our world nonetheless. Pynchon reminds us that art participates in the "Other Side," that atemporal realm where primary processes of mind are accessible. Primary processes of mind, Bateson tells us, contain information and knowledge that the mind need not remain conscious of; as an economy measure, the mind submerges into primary processes "those generalities of relationship that remain permanently true."[58] In rescusitating, through his art, meanings and experiences that our culture has sunken, and in asking us to join him in a noetic awareness of the process by which those meanings are created, Pynchon has begun to show us the way to a consciousness that neither retreats from meaning nor generates pathlogical meaning. And that, I have endeavored to show, is a result of the peculiar artistry with which he used entropy as a root metaphor.

Chapter Eight

CONCLUSION

> There are an infinity of ways of garbling a theory, but only a few (and ultimately, we may believe, only one) of stating it most adequately.
>
> Stephen Pepper[1]

The previous four chapters have looked in some detail at the uses of the entropy metaphor during the late nineteenth century and during the recent decades of our own century. In this we focused specifically, and at length, on the work of Henry Adams, Nicholas Georgescu-Roegen, and Thomas Pynchon; a separate chapter discussed late nineteenth century uses of energy imagery in looking at the work of Brooks Adams, and the background of thermodynamic imagery in more recent times was indicated in the introduction, in portions of the chapter on the history of the idea of entropy, and in some few footnotes to the text in other chapters. We are now prepared to arrive at some judgment of the virtues and flaws of the entropy metaphor as a device through which to interpret the world. In this effort, we will be less concerned with the strengths and weaknesses of particular instances of the use of the metaphor, than with attempting to discern in those uses the archetypal metaphor in its purest, most cogent form. And as we will see, the entropy metaphor has the form of one of the root metaphors that Pepper dismissed as relatively inadequate.

But before we can turn to that task, there are several problems in our treatment of the thinkers reviewed in the previous four chapters that require attention. First, the reader may have found it disconcerting that in the previous chapter (on Thomas Pynchon) and in the chapter on Henry Adams appeal was made to the notion of a "sociology of knowledge", and that in the chapter on Brooks Adams and in the one on the new physiocrats mention was made of ecology and what that field of study indicates for social organization. (Our criticism of Brooks was that he did not articulate the ecologist's brief against Marxism, as did Nicholas Georgescu-Roegen; our criticism of Henry Adams was that he did not appreciate the sociological foundations of knowledge as they were being discovered in the modern world, as did Thomas Pynchon.) If, as has been implied by the parallelism of criticism, ecology and the sociology of knowledge bear some essential relationship to each other and to the idea of entropy, we stand to learn something of the qualities of the entropy metaphor by investigating those connections.

There is, in fact, an essential relationship between ecology, sociology of knowledge, and the idea of entropy. As a thermodynamic idea, the law of entropy played a part in the development of the modern science of ecology. As one of the epigraphs to chapter three suggests, prior to the advent of thermodynamic science our understanding of ecological systems and relationships was quite different from what it is today. We may, along with Donald Worster, bemoan the circumstance that the incorporation of thermodynamic ideas into biology led ecology, in the decades of the 1920s, 30s, and 40s, to view nature as "a reflection of the modern, corporate, industrial system" in which there are "food factories," "outputs" measured in calories, and a basic class distinction between "producers and consumers."[2] Yet, despite the apparent literalness with which the "New Ecology" began applying metaphors drawn from human productive association to natural communities, thermodynamics, by drawing attention to food chains, did bring to some biologists an appreciation of nature as a complex web of relation: all food chains together comprise an ecosystem's "food web".[3] To be sure, within the New Ecology the web was limited conceptually to caloric flows, and some New Ecologists abjured all talk of "community" in nature and all speculation about relations that could not be quantified by being subsumed under thermodynamic categories.[4] But the image of the complex web -- an image articulated with the aid of thermodynamics -- was to become the central image to what some call "Deep Ecology," which seeks to recapture the perspective of an older tradition, that of an Acadian "fellowship" with nature.[5] In deep ecology, the "network" has ontological status: organisms are "knots in the biospherical net or field of intrinsic relations", relations that are so fundamental to the entities caught up in them that they form part of the "basic consitutions of A and B [such]...that without the relation, A and B are no longer the same things."[6]

Thermodynamics, then, figured directly, if at some remove, in the development of the ecological perspective. It did not, however, so figure in the development of sociological interpretations of knowledge. The connection here is more tenuous that that;

it is to be found in the similarity in style between ecology and sociological epistemology, rather than in a rigorous derivation from a shared first principle. In the work of modern sociologists of knowledge -- Thomas Kuhn, for instance[7] -- knowledge is seen to be the product of a social enterprise, that is, an enterprise whose characteristics (and characteristic products) are shaped by the community to which the inquirer belongs. Thus, an examination of how knowledge comes about becomes, first and foremost, not an inquiry into the structure of the cosmos, nor an examination of an individual's perceptual apparatus (though neither of these are denied all importance) but an examination of the complex network of social relations that undergird the act of inquiry, and of the socially shared values and meanings through which perception is filtered. The connection to deep ecology is to be found in the similarity of images: the object of study can no longer be the individual, but must be the characteristics of the individual as related to the collectivity -- and that relationship is seen to be an intrinsic one. As was suggested in chapters five and seven, a theory of knowledge grounded in social and political relations may yet discover in processes of inquiry a pattern, order or regularity with a content applicable to social and political organization, and so redress the political symptoms of the "ontological anomie" that Henry Adams chose, somewhat mockingly, to model with the second law of thermodynamics. On this reading, it is no coincidence that periods of interest in sociological interpretations of knowledge coincide, roughly, with the eras we have identified as being periods in which entropy flourished as metaphor. Durkheim, Weber, and Pareto produced some of their important work in the last decade of the nineteenth century and in the early years of the twentieth; Kuhn's relativist treatment of the history of science, which places the community of inquiry in the role of ultimate arbiter of paradigm choice, was first published in 1962, with a second edition in 1970, and was, for some time, the single most cited work in academic publications. What entropy served to model during these periods, the sociology of knowledge sought to rectify, by discerning within an apparent chaos of relation a more subtle, more complex form of order. This endeavor -- to find subtleties of order in apparently random relations -- is one shared by the ecological perspective.

The second major point requiring clarification before we turn to an evaluation of the entropy metaphor has to do with the degree of consciousness, and literalness, with which root metaphors are employed. I have said that to use a root metaphor literally without being conscious of its metaphoric quality is to risk having one's work mistaken for satire; readers may hardly be able to credit the idea that the excesses of statement that result from such application were not intentional, and, if those readers are not sensitive to the historical development in the sophistication of root metaphor, they may be unwilling to indulge even a classic author the conceit of a thoroughly literal application.[8] There is, in short, something fishy about an instance of root metaphor that approaches too neatly the paradigm case.[9] But this "fishiness" is not simply the product of a too-literal application of a root metaphor, nor of an unconscious application; it results from a use that is at once both unconscious of the metaphoric qualities of the application and too literal in its extension of the root metaphor to new areas. The distinction thus drawn may sound tenuous; but it is supportable, I think, by an appeal to the different characteristics of the entropy metaphor discoverable in the work of the thinkers whom we have examined. Thomas Pynchon used the idea of entropy as an organizing metaphor in his work both consciously and metaphorically; Henry Adams, conscious of the associative leap involved in applying the metaphor to society, used the idea both literally (in satiric comment on modernity) and metaphorically (to model the historical processes that had produced modern society) and his double use here accounts for the complexity of his thought. Brooks Adams, as well, was aware of the associative leap involved in applying thermodynamic ideas to history ("If intellectual phenomena are evolved in regular sequence, history, like matter, must be governed by law. In support of such a conjecture....")[10] but then proceeded to explore the implications of that leap by applying the language and imagery literally. Nicholas Georgescu-Roegen used the idea of entropy both consciously and literally, but unlike the Adams brothers (and like the biologists of whom Worster talks), his usage involved no associative leap: economic activity is grounded in physical reality, which is ruled by the laws of thermodynamics. Wilhelm Ostwald took up the language and conceptual categories of thermodynamics with literalist sincerity, unaware of the associative leap involved in speaking of "social energies" or of happiness as a product of the successful discretionary discharge of energy. Because of this, his work is most nearly a paradigm case of the root metaphor, and is marked neither by the tentativeness of Brooks' formulation nor the awareness of limited scope of Georgescu-Roegen's.

Having cleared up these matters, we are now prepared to turn to the task of evaluating entropy as root metaphor. In this, we will make use of the criteria for evaluation that were developed in chapter two. Those you will recall, fell into three broad groupings, which we called formal, instrumental, and normative. For the convenience of the reader, I will recapitulate them here.

The formal criteria had to do with the ability of the root metaphor to serve as root metaphor, and are suggested by the qualities that all root metaphors share to greater or lesser degree. Successful root metaphors, we noted, are capable of generating explanations or theories with a high degree of structural corroboration, meaning a convergence of a large amount of evidence upon a single point of fact in the determination of that point of fact. They also display a high degree of precision or cognitive determinateness in their explanations of phenomena. Unlike the root metaphor of mysticism, for instance, which can give no cognitive priority to any from among the many possible explanations of natural phenomena it supports, the successful root metaphor will offer either one precise, determinate explanation of a phenomenon, or at least entail a method that holds forth the hope that further factual observation will produce such an explanation. This suggests that the categories of the root metaphor are turned to cognitive uses, i.e. come to shape the holder's vision of how truth is determined. And, while we noted that for many of their partisans, root metaphors were not tentatively held ontological propositions, so that to speak of "world hypotheses" or "world theories" was technically incorrect, successful root metaphors do survive through ad hoc elaboration and articulation in ways that are consistent with their fundamental categories, so that we can say the successful root metaphor will be capable of expansion into areas of previously unassimilated facts; if not as hypothesis or theory, then as an article of faith. As an ordering vision to which no fact is irrelevant, a root metaphor must, if it is to survive, either assimilate any fact presented to it or, through some argument consistent with its categories, challenge the "facticity" of the fact itself.[11]

In arguing that the ultimate grounds for evaluation of a root metaphor are political, we deviated from Pepper's analysis (though his analysis assumes that ordering visions are social, and hence, I would say, political phenomena) and set up our second and third orders of criteria. The second range of criteria -- which we called instrumental -- had to do with how well the root metaphor could render current political institutions and affairs comprehensible, and the third order of criteria would have us pass judgment on the normative content of the root metaphor.

We begin, then, with a discussion of the entropy metaphor as evaluated against the formal criteria. As a first step, it is useful to characterize the root metaphor and the world vision it suggests.

Entropism, as a metaphysical hypothesis or faith, is a world perspective that takes Maxwell's Demon as its archetypal image. All the entities of the world are distinguishable into two categories: entities that sort low entropy (and in fact, this is the root metaphor's definition of a living thing) and those that don't. That is, for this vision, there are beings who sort and there are potential objects of the sorting process. (The categories are not mutually exclusive: some sorting entities serve as the low-entropy intake of other sorters.) In its focus on "energy" (or one of its cognate terms: "low entropy", "negentropy", "information") entropism as metaphysical hypothesis or faith bears a marked similarity in form to most pre-socratic philosophies. Those philosophies, Pepper tells us, were founded on the root metaphor of "generating substance" -- a substance that was the fundamental element giving rise to all things. The generating-substance world hypothesis has a form characterized by three categories of objects of cognition: 1) a generating substance (or perhaps several); 2) principles of change, such as "shaking out", "felting", compression and rarefaction, affinity -- or the second law of thermodynamics; and 3) generated substances produced by 1) in accordance with 2).[12] To Thales, the generating substance was water; to Anaximander, it was the apeiron or infinite; to Anaximander, air. Entropism as a variant of the generating substance hypothesis is most obvious in the work of Wilhelm Ostwald, who took energy to be the generating substance: "By the term matter, we...indicate only certain complex forms of energy..." and "every change, and consequently every process, may be fully described by a statement of the kind and amount of energy, considered with respect to time and place, that has undergone conversion."[13] But other versions of the generating substance theory give primacy to other categories: Heraclitus, for instance, proposed believing in generating change and apparently denied the reality of permanent substance; his focus on process is but an extreme version of the position advanced in more moderate terms -- and in contemporary, thermodynamic terms -- by Nicholas Georgescu-Roegen. We can distinguish, then, a variant of the generating-substance world hypothesis founded upon the entropy root metaphor, a variant that focuses upon the first category, which we will hereafter refer to as "energism". Because the generating substance itself can be understood in entropy terms -- because energy is one form of low entropy -- we will continue to use the term "entropism" to describe any world theory, hypothesis, or vision that applies thermodynamic content to the categories of the generating-substance hypothesis.

As a generating substance theory, entropism is prey to the inadequacies that are typical of the genre. One measure of the inadequacy of a world theory is the range of fact that it consigns to the "unreal", that is, the realms of structural corroboration which, being incapable of assimilation to the categories of the theory, are dismissed as mere appearance. Typically, the generating substance theories attain the degree of structural corroboration they do only by demeaning as mere appearance the apparent diversity of manifestation of substances in the world, and by carrying the terms in which the generating substance is expressed into usages that are, to non-partisans of the theory, apparently metaphoric. Thus, Thales held that water is all -- a statement that a modern mind would tend to interpret as metaphor in order to keep from attributing an obvious absurdity to a founder of philosophy. Similarly, "energy" of some sort is, to the energist, discoverable in human relations, in the powers and capacities of the mind, in social groupings, as moving "force" in history. The desire to avoid the appearance of inadequacy explains the energy with which Rifkin, for instance, denies that there is metaphor in his use of the term entropy (see chapter one), and the dogged literalness with which Ostwald attempted to express theories of happiness and social relation through the categories of thermodynamics. In contrast, Georgescu-Roegen's acceptance of a limited scope for an economics grounded in thermodynamics, which amounts to an admission that entropy can not serve as the root metaphor for a cognitive framework of unlimited scope, accounts for the tone of reasonableness and sanity in his work. As Henry Adams said (if I may paraphrase a bit): a world theory "would admit its failure if it admitted that man, the most important of all its subjects, could not be brought within its purview."[14] Georgescu-Roegen admitted that failure of entropism; Rifkin and Ostwald could not.

The foregoing suggests that what an inadequate theory can gain in scope of structural corroboration through imaginative application is compensated for by a corresponding loss in adequacy of precision. Assertions that have the form of testable propositions turn out, upon closer examination, to be tautologies whose circularity is embedded in the broadened scope allowed to the terms in which the generating substance is described. It may be, as Brooks Adams suggested, that civilizations decline when their races run out of "energy", but as we noted this formulation is less of an hypothesis than an untestable axiom -- i.e. a statement which, though affording the opportunity for structural corroboration, is, by its nature, immune to criticism that founds itself upon the statement's absence of multiplicative corroboration. The key terms of the root metaphor lose precision in their application beyond the "common sense" cognitions that formed the basis of the root metaphor, for an arena that a world theory cannot enter for structural corroboration, but which it cannot ignore or dismiss as unreal, it can enter only as metaphor. Notwithstanding the successes of entropism in achieving a high degree of precision of structural corroboration in economic affairs and biology, and despite the fact that in the history of science metaphoric extrapolations of terminology have served to "prepare the mind to make more precise investigations,"[15] it is unlikely that the generating substance hypothesis will achieve any greater precision in its application to social and political affairs in its entropist formulation.

There are two reasons for this. One has to do with the shortcomings of the terms and categories of entropism as they are applied in these realms. We noted these shortcomings when we reviewed the work of Brook Adams, and we need not belabor them here, except to note that in concluding this we are guessing that those terms and concepts are likely never to have a quantifiably determinate content in these fields. The other reason has to do with an historical dynamic that has brought our understanding of metaphor into the realm of the noetic. Ironically, work by thinkers such as Pepper has formed this dynamic -- ironically, because in bringing the use of metaphor into the realm of the noetically appreciated, Pepper and others have contributed to our modern disquiet with any organizing system that smacks too obviously of metaphor taken literally. And yet, it is only in taking metaphor literally -- only in hypostatizing the key terms of a world hypothesis -- that a world hypothesis can enter areas of potential structural corroboration far removed from the discipline or arena in which the theory's root metaphor originated. Either we take sides with Brooks, and ascribe literal meaning to terms that are essentially metaphoric in signification, or we take sides with Henry, and announce (or, more accurately, smirk in our private correspondence) that the terms are being used metaphorically. In our age, Brooks' solution will more and more be seen to be unsatisfactory; and Henry's approach, though more honest in this sense, yet denies the root metaphor the structural corroboration of that field. Precisely because we are now more aware of the operation of metaphors as patterns in our thought, root metaphors will no longer be able to serve as foundations for world theories or world hypotheses of unlimited scope.

We may summarize our conclusions so far by saying that against the formal criteria promulgated by Pepper, entropism stands convicted of being a relatively inadequate root metaphor -- but its inadequacy has as much to do with our current appreciation of metaphor as with the inherent limitations of entropism as a world vision. Any future root metaphor is likely to encounter the same difficulties, for each root metaphor is likely to require, as part of its development, a period in which its key terms and categories admit of no great quantity of precise structural corroboration. The choice seems to be: accept a conscious literalization of a root metaphor, and a consequent vagueness, as the price of adequate scope, or forego the attempt to create out of a root metaphor a universal or world theory.

This state of affairs would be regrettable, were the ideal of unlimited scope not a misguided one.

The flaw in the ideal of unlimited scope can be found by examing the absolutism implicit in Pepper's "world hypothesis" hypothesis, an absolutism that is partially indicated by the epigraph chosen for this chapter.[16] Although Pepper states that "we need all world hypotheses, so far as they are adequate, for mutual comparison and correction of interpretive bias,"[17] we need them only because our knowledge is limited and imperfect; Pepper still accepts as an ideal the world hypothesis of perfect adequacy, perfectly universal scope, perfectly complete structural corroboration. That ideal leads him to hold that "root metaphors are autonomous" and that, because of that autonomy, "they are mutually exclusive. A mixture of them, therefore, can only be confusing."[18] The passage in which he dismisses eclecticism is worth quoting at length:

> ...is it not true that the mechanistic theory seems to be particularly effective in the field of the physical sciences and rather shallow in the field of values, and is not the organistic theory rather strained in the field of the physical sciences and strong in the field of values? Would not an eclectic theory which accepted the mechanistic interpretations of physical facts and the organistic interpretations of facts of value be a more adequate world theory than either pure mechanism or pure organicism?
>
> But would it? We must not forget that the main strength of a world hypothesis comes from structural corroboration. That means that the greater the spread of corroborative fact, the greater the cognitive reliability of the interpretations of each separate fact and field of facts. Now the cognitive strength of both mechanism and organicism lies in their relative adequacy of unlimited scope. If their scope were limited, their interpretations would lack full corroboration. We find them credible precisely because their scope is unlimited. But the eclectic suggestion amounts to a limitation in the scope of both interpretations. In the eclectic theory the interpretations of physical facts would not be corroborated by the interpretations of value facts, and vice versa. The eclectic theory would actually lack universal scope and would not literally be a world theory at all.[19]

What is wrong with this argument is its implicit assumption of the autonomy of world hypotheses. If the failure of an eclectic combination of world hypotheses is to be adduced as evidence for the claim that world hypotheses are autonomous, one can hardly assume such autonomy in describing the failure of eclecticism -- or, one can so assume, but one can not do so and present a logically compelling argument. The assumption of autonomy lies buried, in this argument, in the claim that we find world hypotheses credible just to the extent that we find them unlimited in scope; so long as we hold world hypotheses accountable to the criteria of unlimited scope it is hardly likely that we will accept as adequate a world hypothesis that admits it is a partial vision, standing in need of supplementary explanations and perspectives borrowed from other world hypotheses in order to account fully for the world. The absolutism that this requirement of world hypotheses generates is misguided, in that it replicates, at the metaphysical level, the paranoid style of political conceptualization characterized by Hofstadter; it asks us to accept the premise that all phenomena can be viewed from the vantage point of a single vision, with the consequent acceptance of ambiguity and "double vision" as being only (more or less) temporary requirements of the shortcomings of our philosophy.

Because of this absolutism, Pepper is willing to view the world hypotheses constructed on root metaphors as ideal types, as cognitive structures that "few books...exhibit...in their purity."[20] The fact that they are so rarely manifest as "paradigm cases" is a bit of disconfirming structural "corroboration" for the world hypothesis theory itself, and Pepper might have appreciated this had he not allowed himself to fall prey to the fallacy of hypostatization of terms. That is, had Pepper not let the abstraction "world hypothesis" lose contact with the data from which its structural corroboration is drawn, if he had not let it become something of a hollow term, he might have found room in his theory for the fact that root metaphors often co-mingle and shade into one another. (He does in fact note that this happens, but he views it as a flaw -- as something against the essential nature of world hypotheses, as an unreal element barely requiring explanation.) Pepper claims as a maxim of the root metaphor theory the assertion that "Concepts which have lost contact with their root metaphors are empty abstractions";[21] we note here that the root metaphor theory itself has no root metaphor, but presents itself as an attempt to "bootstrap" ourselves into knowledge by discovering in the existence of root metaphors, and in the logic of their function, the foundations of knowledge.

Despite the fact that root metaphors are social phenomena, Pepper's work is not an instance of sociology of knowledge. One can hardly be so cavalier as to dismiss the evidence of how root metaphors and world hypotheses are, in fact, found in society and still claim to be a sociologist of knowledge. One could use the root metaphor theory as a foundation for the sociology of knowledge, but to do that one would have to ground the theory in root metaphors as they are, rather than (as Pepper has done) working backward from the "fact" of perfectible world hypotheses, to world hypotheses as they are (that is, as he sees them: imperfect, but struggling toward perfect adequacy of scope and precision), to the root metaphors that give rise to them. Pepper is concerned to explain cognitive social phenomena, but because he begins not with social phenomena, but with an ideal cognitive device he has abstracted from social experience, his work is an instance of an epistemology grounded not in social and political relations but in metaphysics -- specifically, the assumption that phenomena immanent in the world are but pale shadows of ideal, perfectible forms.

Pepper, then, grounded his epistemological theories in an ontological doctrine, rather than in social and political phenomena. In beginning not with root metaphors as they are, but with the problem of cognition, he was led astray. "Knowing" is not all that humans seek out of life; cognition is not the sum total of human experience and purpose. Along with -- perhaps even prior to -- the perceived need for knowledge is a perceived need for connection, for discerning one's place in an ordered milieu, to feel as if some few, at least, of the threads and strands of existence have an anchor in one's being, one's life, one's circumstances. One cannot develop cognitive categories out of popular novels, or even, generally, out of epic literature; but these works of art appeal to us nonetheless, for they offer us narrative and thematic elements that help us to perceive order in our existence. Root metaphor as well -- as the linguistic shadow cast by shared patterns of connection-making in our thought -- provides such a thread, and an appreciation of this quality of root metaphor might have aided Pepper in allowing more room in his meta-theory for ambiguity and complementarity among root metaphors as world-ordering devices.

This extended criticism of Pepper is germane to our evaluation of the entropy metaphor, for the formal criteria that Pepper offers for the evaluation of root metaphors are infected with absolutism. By those criteria, we judged entropism to be an inferior world hypothesis: it is, in many fields, vague and incapable of further precision, and those arenas in which it is capable of precision are relatively limited, being confined primarily to physical processes and relationships. But throughout this work our focus has not been on the cognitive value of the world hypotheses that can be founded on the entropy metaphor, but on the esemplastic or world-ordering function of the root metaphor itself. By the criteria for judgment that that function suggests (the second and third broad ranges of criteria we have discussed), our judgment of entropism need not be so absolute. We turn now to an examination of the explanatory or instrumental power of the entropy metaphor, and to an evaluation of the characteristic political vision that the root metaphor suggests.

One way of discovering both the explanatory power and the normative biases of a root metaphor is to look at the reasons for its popularity, at the ways it is actually manifest in the thought of a culture. There are, I think, several discrete but sometimes inter-related reasons behind the popularity of entropy as metaphor (and root metaphor), reasons that have to do with its power to articulate widely shared perceptions, normative predispositions, and patterns of connection making. I offer them here, with explanations.

First, entropy connotes disorder. This means it has a natural constituency among those living through a period of political crisis; as accepted modes of ordering political reality come under challenge, and before reformed, revised, or new institutions are fully operational, the political arena will be experienced as chaos. This suggests another, anticipatory use: if, as Wolin says, in times of political crisis accepted modes of thought come into question, we might also expect that those who wish to question accepted modes of thought will perceive the world to be on the brink of crisis -- a condition evoked by metaphoric appeal to the idea of entropy. Popularity of the entropy metaphor in applications to society, to political relations, or to history could thus be a sign that the root metaphor of the society is changing -- or that some who use the entropy metaphor would like it to change. It need not change to entropism, however; the entropy metaphor could be a transitional or mediating root metaphor.

Second, entropy is pessimistic. Its use as a metaphor is a convenient shorthand for articulating a sense that things are running downhill, falling apart, getting worse. It can thus not only model a condition of social or political disorder, but describe the process by which that condition was produced. One need not be a partisan of any particular political camp in order to resort to the entropy metaphor: those who long to preserve the _status quo_ (or to restore the _status quo ante_) will see impending change as impending chaos, and those who long for and work to bring about change could see their efforts as the last best hope of forestalling the entropic degradations of the political world as it has been. Because it connotes decline through time, the popularity of entropy as metaphor is related to the cult of nostalgia that modern society calls forth (and then exploits: in advertising, in the escapist experiences that are commercially offered, in politics). There is some irony in the way that modern nostalgia often returns to a sanitized, idealized America of the 1890s, for it was just this world that Henry Adams sought to escape in turning to the middle ages.

Third, and perhaps most obviously, the particular variant of the entropist generating-substance world hypothesis we are calling energism will have an increased appeal during times of (perceived) crisis in the supply of energy to a culture's economic system. Just as in times of political disorder, the ordering function of our belief systems will appear to be the essence of political relations, any time an economy is threatened with a decline in or a disruption of its supply of energy, energy will come to be appreciated as an important -- perhaps the only -- source of value. The American politic-l crisis of the 1890s was not initiated by an energy crisis (except, perhaps, in a metaphoric sense, to the extent that it was precipitated by a policy of tight money and to the extent that money is a form of embodied low entropy), but during that time the importance of energy was being suggested to many thinkers by the recent successes in integration of various sciences, through the good offices of thermodynamics. The discovery of radium, and with it the discovery of a new source of energy in radioactive decay, occurred shortly thereafter, emphasizing the point. In the 1970s the energy crisis had another effect: as increased energy prices encouraged conservation measures, the idea of entropy gained a currency it had not before enjoyed. Entropy is the process that insulation attempts to slow down, and nearly every handbook on solar design or retrofit attempted a brief exposition of the idea.

Fourth, the use of entropy as root metaphor lends the authority of science to an argument or image. There are several reasons for this being a source of appeal. Science remains an authoritative source of knowledge in our culture; if, as Michael Walzer suggests, thinkers are "driven to escape" from disciplines in which knowledge is less certain in order to find a point of fixity in an authoritative realm,[22] we should not be surprised to find political and social thinkers turning to science as a stock of analogy, image, and metaphor. Because, as Walzer also notes, political knowledge is essentially probabilistic, entropy -- the first general physical law to be explicitly probabilistic in character -- seems to be all the more fitting as an authoritative model, analogue, or metaphor. And the entropy metpahor appeals even to those who view science as a source of much evil in the world. That appeal need not always be ironic, as it was for Henry Adams, or a sign of lack of thought, as it is for many of the entropy metaphor's recent popularizers. Behind the appeal of the entropy metaphor to some of the modern romantics who use it is an attenuated form of the fallacy of clearing the ground: if science itself can be made, through the entropy metaphor, to suggest that a culture based on science is in decline, the way seems clear for alternatives. Technically, demonstration of the shortcomings of one theory (or one world-ordering vision) has no bearing on the attempt to demonstrate the value or worth of another. But here logical technique falls short: with world visions we are not so much concerned to demonstrate their "truth" or "falsity" as we are to argue for their appropriateness, and because this is a matter of relative degree, clearing the ground can be an acceptable rhetorical strategy. Entropy thus has, for some modern romantics, all the appeal of the _tue quoque_ ("what about you?") form of argument. That appeal is co-mingled with a sort of ideational totemism: if one may gain the strength of a lion by eating of its muscle, so that one may hunt it, perhaps one gains an advantage on science by partaking of its ideas and using them as metaphor.

Fifth, entropy is truly a ubiquitous process, lying behind all change in the physical world. One need not fully accept energy as a generating substance to see entropy as the fundamental principle of change. Death, decay, rust, and rot are obvious manifestations of the entropy process; less obviously but no less justifiably one may detect the specter of the second law behind such activities as housework, eating, shopping, performing maintenance chores, purchasing and using fuel, splitting wood (or atoms) -- in fact, behind any purposeful activity directed toward bringing about a change over time. "Entropy is a law of dynamics," not merely thermodynamics, Nicholas Georgescu-Roegen tells us; wherever there is change, there is entropy.

Sixth, entropy is a law of nature, and to see it at work in the affairs of humans is to suggest, subtly, that those affairs are beyond our control. What we cannot control, we cannot have responsibility for; one source of the appeal of entropy as a metaphor for human relations has to do with the escape from empowerment that modern technology not only allows but fairly demands.

(In this sort of application entropy as root metaphor supports social relations that technology has engendered -- as is fitting for an idea that owes its existence to the technical search for efficient use of power.) Just as technology is an "ethical armor", distancing the impact of our activities so that the causal connections, and hence our responsibility for consequences, are obscured, entropy as metaphoric mirror reflects our sense of helplessness. Some of its perpetrators seem seduced by the metaphor's suggestion that in disempowerment lies our only hope of innocence. "When a supervisor victimizes a worker," writes one doctor, in an effort to clarify modern human relations, "a terrible entropy often results in a wife being beaten."[23] Thus does entropy teach us to speak in a passive voice.

Finally, one source of the appeal of the entropy metaphor has to do with entropy's status as a law of chaos. The phrase itself is an oxymoron, and in the tension it (and probability theory in general) embodies we can see, in fine, an element of the human condition: humans have a need to experience a dialectical tension between order and disorder, the knowable and the recondite, the predictable and the risky. Throughout most of human history, we have worshipped a god of Order while fearing the dark agency of Chaos. (While an important minority voice in history has celebrated the liberating quality of chaos -- Bakunin, for instance -- that celebration valued chaos only as a precondition to discerning new forms of order. Dramatic social change has always been mediated by an appeal to a different vision of order, never by an appeal to pure chaos. Sometimes the new vision of order is more subtle than the one it seeks to replace; sometimes it cannot be fully perceived until the old order is swept away.) God and Satan, the elect and the damned, the self-righteous and the humble preterite, the free market and special interests, central planning and anarchic competition, good patriots and fifth columnists, jingoistic nationalists and critical, thoughtful citizens: these are the dialectical pairs through which we cast our vision of the ideal order, and through which we generate our explanations of the failure of reality to achieve the ideal. To the second term in each pair we may add entropy, the modern force for disorder, complemented by energy, the organizing principle that maintains the integrity of structures and systems it flows through.

If humans have a need to sense chaos as a possibility, the success of our culture's domination of nature suggests another source of popularity for the entropy metaphor. Instead of fleeing chaos, and even more than being morbidly attracted by it, we now positively desire it. We once knew nature as chaos, but now chaos itself is an endangered species. As idea it has been domesticated by the second law and the laws of probability, which describe its genesis and logos; as an immanence in the world it has been brought to the brink of extinction by the pressure of population and the plow. We should not be surprised to find that the law of entropy captures the imagination of a culture that finds it necessary to manage wilderness bureaucratically -- and to issue permits to those who sojourn there. Where once we were surrounded by chaos, we now find only order; all the chaos that is left to us is the chaos of our own devising. As Wolfgang Giegerich has pointed out, our nuclear weaponry is a potential for chaos as unprecedented in human history as the ubiquity of our domination of nature.[24] Perhaps there is a first law of chaos, a law of conservation of disorder; it is as if all the chaos in the world had been laboriously condensed to a point, and locked within a cold and steely Pandora's bomb; the result has been to impale our culture on the fallacy of the excluded middle. We can have, it seems, total order or total chaos, and no middle ground in between. The contemporary lesson of the myth of Pandora's box is not that we are "Fallen", but that life at either extreme is untenable. Entropy as root metaphor keeps at least the thought of disorder alive as possibility, though as a shadow reality, abstract, invisible, and not quite immanent in the world, it is poor consolation.

Several conclusions can be drawn from these sources of the entropy metaphor's appeal. First, it is evident that the entropy metaphor, like other rich metaphors, allows for contradictory applications[25]: it is equivocal on some of the crucial questions affecting political organization. At the very start, entropy suggests both that the human struggle for order is hopeless, and that we can achieve order only by living in harmony with the forms of order that the sun's energy -- our daily budget of low-entropy "income" -- has helped to create and maintains. We need not accept entropy's implicit identification of "homogeneity" with "chaos", but even in rejecting that identification we find no way to make one of these voices concede to the other. This is because the maintenance of any physical structure requires low-entropy inputs, and the process of entropic decline that makes this true doesn't care at all whether we count the system of differentiated structure (with an enclave of low entropy here, and higher entropy out there) as ordered, or whether we apply that term to the homogenized system-at-equilibrium it will, over time and because of the entropy process, become. Physical structure is a rarity in the universe, because usable energy is rare, and becoming scarcer all the time. To be sure, there is physical structure (and order) in nature, but -- according to the vision of the entropy metaphor -- it is "unnatural": it is a temporally and spatially parochial pocket of low entropy maintained only by the enormous entropic losses of our sun. While thermodynamics suggests to some that nature provides an image of order maintained by solar energy "through-puts", to others the ultimate thermodynamic condition that we as humans labor under suggests that nature ought to be looted, right now and as quickly as possible, for the stocks and flows of low entropy we require to maintain the physical systems we desire. At issue, as Georgescu-Roegen pointed out, is how long we humans will maintain an industrial culture; and the thermodynamic injunction to "waste no energy!" offers no precise insight into the problem of intergenerational obligation that lies at the heart of that question.

Entropism offers us a foundation for a materialist understanding of politics: all politics, in this vision, is concerned with the pursuit and division of scarce low entropy. This perspective sheds some light on relations between nations, perhaps, and encourages us to see the relationship between debtor and creditor classes as central to political history; but, like other materialist interpretations of politics, it does not illuminate with much clarity the moral dimension of politics, the dimension that suggests (among other things) that in participation in public life lies the path to full and complete human development. Entropism thus reinforces and explains a long-standing tendency in American political life: politics, for most Americans, is an arena entered into only in self defense.

We are now prepared to distinguish more clearly between the instrumental and the normative content of the entropy root metaphor. Like other materialist interpretations of politics -- notably, Marx's -- entropism explains much (though not all) of politics-as-it-is, without offering great precision in its view of what politics ought to become. Unlike Marxism, entropism does not point to a final transcendence of politics as it understands it: the thermodynamic constraints within which we operate offer no hope of "bootlegging" entropy, and thus no hope of escaping the competition for scarce low entropy. But when it comes to the creation of political institutions that would allow us to recognize and to deal with this fact, entropism's equivocation returns: one group of partisans of the entropy metaphor celebrates Jeffersonianism, and the image of decentralized political units, each with a some degree of "low entropy" self sufficiency; another finds in the laws of thermodynamics the ultimate justification for an enlightened technocracy, a centralized, garrison state dedicated to maximizing the efficiency of use of precious low entropy -- a thing too valuable to allow anyone the freedom to waste. One would think that because a calorie is a calorie, it ought to be possible to evaluate, as a purely technical matter, the relative efficiencies of the two kinds of energy delivery systems at issue here, the decentralized and the centralized. But such an effort is hampered by the fact that there is no convenient and telling measure for material low entropy; as Georgescu-Roegen put it,

> We must refrain from speaking of the entropy of matter as a measurable entity. There is a measurable entropy for energy because energy is homogenous [i.e., all forms of energy can be measured in a common unit, or, what amounts to the same thing, all forms of energy are convertible, one into the other]; matter in bulk is instead heterogenous.[26]

Because most forms of material low entropy are incommensurate with other forms, and because the two energy delivery systems make use not only of different amounts but different kinds of material low entropy, there is no technical, thermodynamic resolution of the question as to which is more efficient. Which is to say, despite entropism's suggestion -- noted in different ways and with different degrees of clarity by Georgescu-Roegen, Brooks Adams, and Wilhelm Ostwald -- that the essence of politics is competition for scarce low entropy, entropism cannot reduce politics to a science, cannot resolve questions of political order into technical questions of energy efficiencies.

Despite the inability of entropism to offer precise prescriptions for political organization, it does offer detailed prescriptions for the conduct of our economic affairs, and characteristic explanations of some economic phenomena. Entropism alone uncovers two distinct roots of the systemic inflation that besets industrial economies: the need for some form of debt repudiation, and the increasing low-entropy cost of low entropy. It offers an esemplastic vision that brings conceptual order to a number of fields -- economics, biology, parts of ecology -- and reaches others vaguely, if at all. How does the world look to one who views it through lenses shaped by the entropy metaphor? If one cannot resist hypostatizing its major categories, the world will seem to be one vast mechanism, running down, and its interconnections and continuities will be such that the vision it yields will be the envy of any true paranoid. Or, alternatively, if the world is not to run down, that is only because the partisan of entropy as a world hypothesis of unlimited scope turns entropism into a variant of mysticism, and finds in the universe some transcendental energy or energies beyond the reach of the second law. To those who can resist the hypostatization of terms, entropy suggests a characteristic vision of order in the world, but it is one that centers on the affairs of economic life and the thermodynamic aspects of nature, and edges out into the vaguer reaches of metaphor when applied to social and political organization, history, morals, and the other affairs of the polis. This is not to say that the metaphors that result may not be pleasing; only that we must be wary that the understanding such metaphor brings to these fields must be as much a product of our own desire to discern connection and order in the world as it is the result of anything inherent in the objects of cognition themselves.

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Notes to Chapter One

1. Wayne C. Booth, "Metaphor as Rhetoric: the Problem of Evaluation," pp. 47-70 in Sheldon Sacks, ed. On Metaphor (University of Chicago Press, Chicago: 1978), p. 69.

2. The enormous heat energy contained in the ocean can not be put to practical use because it exists at a temperature lower that of the other components of any system that would employ it. One could use this energy by extracting work from the temperature gradient between the ocean and an iceberg, or between the layers of ocean water itself. In these cases, the iceberg or the colder layer of water become the "heat sink" for the system, and whatever heat energy is within them (a considerable amount, given that in the absence of any heat energy they would exist at absolute zero, or -273 degrees centigrade) is bound energy.

3. Stephen Pepper, World Hypotheses: A Study In Evidence (University of California Press, Berkeley: 1948).

4. Stephen Salkever, "Freedom, Participation, and Happiness," Political Theory, August 1977, pp. 394-413. Salkever does not make the connection to root metaphors.

5. The phrases are from, respectively, Henri Bergson, Creative Evolution (Henry Holt and Co., New York: 1911), p. 243; also quoted in Max Jammer, "Entropy," Dictionary of the History of Ideas Vol. III, Philip P. Wiener, editor-in-chief (Charles Scribner's Sons, New York: 1973), p. 118; Nicholas Georgescu-Roegen, "Energy and Economic Myths," in Energy and Economic Myths (Pergamon Press, New York: 1976), p. 8; Ibid.; and Rudolf Clausius, quoted in Martin J. Klein, "Maxwell, His Demon, and the Second Law of Thermodynamics," American Scientist Jan.-Feb. 1970, pp. 84-97, p. 88.

6. William Gass, On Being Blue (David R. Godine, Publishers, Boston: 1976), p. 21.

7. Edward Mendelson, "Gravity's Encyclopedia," pp. 161-195 in Mindful Pleasures: Essays on Thomas Pynchon, ed. by George Levine and David Leverenz (Little, Brown and Company, Boston: 1976).

8. John Rodman, "The Dolphin Papers," pp. 13-26 in The North American Review, Spring, 1974, p. 15

9. Dante Germino, "The Contemprorary Relevance of the Classics of Political Theory," pp. 229-81 in *The Handbook of Political Science*, Vol. I, Fred I. Greenstein and Nelson W. Polsby, eds. (Addison Wesley Publishing Company, Reading, Mass.: 1975), p. 233.

10. Robert Nozick, *Philosophical Explanations* (Belknap Press, Cambridge, Mass.: 1981), p. 5; pp. 1-24, *passim*.

11. See Alfred North Whitehead, *Science and the Modern World* (Mentor Books, New York: 1948), pp. viii-ix, p. 4. The assertion that stories serve an important world-ordering function can be supported by several arguments. In the interest of brevity, I offer two: the appeal to authority and the appeal to popular -- or at least widespread -- belief. No less an authority than Plato would have censored the products of the poet's art (which, it hardly needs pointing out, were not so much poetry as we understand it today as narrative verse, put in rhyme and meter to aid memorization) for their effect on the beliefs of the citizens of the city; see the *Republic*, stanzas 381d-393e (pp. 59-72 in Allan Bloom's translation: Basic Books, New York: 1968). To be sure, Plato objected to the mimetic quality of the poet's art, in which the poet represented himself and his words to be something that they are not (603c-607d), and thought that the essence of such mimesis was such that those who accepted poetry as providing exemplars for human behavior could be citizens only of a city where "pleasure and pain," rather than "law and argument", were joint kings (607a). But this criticism of poetic narrative is founded on the idea that poetry *does* provide exemplars and models through which people interpet their lives, which is the point I am making. Other authorities could be cited: Malinowski thought that myth served as an important source of legitimation for the customs and institutions of a culture, which is to say myths "rationalize", provide explanations of, or *order* those customs and institutions; Lang thought myths to be aetiological in import. See G. S. Kirk, *The Nature of Greek Myths* (Penguin Books, Middlesex, England: 1976), pp. 53-4 and 59-60. In fact, so many thinkers have pointed, in different ways, to the world-ordering function of narrative that the appeal to authority can become a form of argumentium ad populum. See, for instance, the sources cited by Brian Wicker in *The Story-Shaped World* (University of Notre Dame Press, Notre Dame, Indiana: 1975). Some find story telling to be the definitively human activity: "...the story of mankind is the story of Story itself. It was not the thumb, erect posture, or the ability to make tools that gave man his start. Apes make tools, as Jane Goodall discovered.... What got people out of the trees was something besides thumbs and gadgets. What did it...was a warp in the simian brain that made us insatiable for patterns--pattens of sequence, of behavior, of feeling--connections, reasons, causes: stories." Kathryn Morton, "The Story-Telling Animal," *New York Times Book Review* December 32, 1984, p. 1.

12. I owe this insight to Kathryn Davis.

13. Henry Adams, Mont-Saint-Michel and Chartres, pp. 296-7 in the Mentor Classic Edition (New American Library, New York: 1961).

14. Pepper allows that "paradigm cases" of the root metaphors he discusses are rare: See Stephen Pepper, "Metaphor and Philosophy," printed as an introduction to a special issue of The Journal of Mind and Behavior, vol. 3 #3 (Summer 1982), p. 203. See also World Hypotheses, p. 149.

15. Hazel Henderson, Creating Alternative Futures: The End of Economics (Berkley Publishing Corporation, New York: 1978) pp. 83-4.

16. Harold J. Morowitz, The Wine of Life and Other Essays (Bantam Books, Inc., New York: 1981), pp. 52-55.

17. Jeremy Rifkin with Ted Howard, Entropy: A New World View (Viking Press, New York: 1980), pp. 6, 4.

18. Ibid., p. 8. "There will be those," Rifkin writes, "who will stubbornly refuse to accept the fact that the Entropy Law reigns supreme over all physical reality in the world. They will insist that the entropy process only applies in selective [sic] instances and that any attempt to apply it more broadly to society is to engage in the use of metaphor. Quite simply, they are wrong." But then, Rifkin goes on to apply the concept of entropy in some rather tenuous ways. "The chief cause of disease is the dissipated energy created by our energy base of non-renewable resources," p. 181 (his way of saying that industrial pollution is now our chief cause of disease; but most of that disease is caused by entropically degraded matter, not energy); "a gut reaction to a situation is more reliable than a reasoned decision....the usual explanation is that one's intuition or instinct is generally more closely tuned to the reality of what's occuring. That's true, and it has everything to do with the second law," p. 166; "Anyone who's been unfortunate to live right smack in the path of a highway construction route has felt the effects of the second law personally," p. 145; "Decentralized political democracy is desirable, not just on moral or philosophical grounds, but also because it minimizes energy flow-through and, as a consequence, reduces the accumulation of disorder," p. 210; "The practice of meditation is designed [my emphasis] to slow down the wasteful expenditure of energy," p. 235; etc., etc. There will be those, Rifkin might have foreseen, who will agree that entropy reigns supreme over physical reality and yet disagree with his implied claim that community energy, spiritual energy, intellectual energy and political energy are physical entities.

18. Continued

For Hobbes on metaphor, see _Leviathan_, pt. I, Chapter 4, pp. 34 and 40 in the edition edited by Michael Oakeshott (MacMillan Publishing, New York: 1962). For Locke on metaphor, see _Essay Concerning Human Understanding_ Book 3 Chapter 10, p. 285 in the edition edited by Maurice Cranston (Collier MacMillan Publishing, Ltd., London: 1965).

19. Nicholas Georgescu-Roegen, _The Entropy Law and the Economic Process_ (Harvard University Press, Boston: 1971); Norbert Wiener, _The Human Use of Human Beings_ (Anchor Doubleday, Garden City, New York: 1954); Frederick Soddy, _Wealth, Virtual Wealth, and Debt_ (Allen and Unwin, London: 1926); Ilya Prigogine and Robert Herman, "A Two-Fluid Approach to Town Traffic," _Science_ 204: 148-151 (13 April 1979).

20. Sheldon Wolin, _Politics and Vision_ (Little, Brown and Company, Boston: 1960), p. 19.

Notes to Chapter Two

1. Donald Davidson, "What Metaphors Mean," pp. 29-45 in On Metaphor, ed. by Sheldon Sacks (University of Chicago Press, Chicago: 1978), p. 29.

2. "Metaphor," in The Princeton Encyclopedia of Poetry and Poetics, Alex Preminger, ed. (Princeton University Press, Princeton, New Jersey: 1974), p. 490.

3. Owen Barfield, "Poetic Diction and Legal Fiction," pp. 51-71 in Max Black, ed., The Importance of Language (Prentice-Hall, Inc., Englewood Cliffs, New Jersey: 1962), p. 52. The idea that tropes lie on a continuum comes from Barfield, also; the terms "vehicle" and "tenor" were popularized by I. A. Richards, and the notion that a metaphor evokes its meaning through a "system of associated commonplaces" that the reader reconstructs is advanced by Max Black in "Metaphor," pp. 25-47 in his Models and Metaphors (Cornell University Press, Ithaca, New York: 1962).

4. Barfield, p. 55.

5. Other sources I found helpful in understanding metaphor include Douglass Berggren, "The Use and Abuse of Metaphor," in Review of Metaphysics vol. 16 (1962-63) pp. 237-258 and pp. 450-472; "Metaphor" by Monroe C. Beardsley in The Encyclopedia of Philosophy vol. 5 pp. 284-289 (MacMillan Publishing Co. Inc., New York: 1967); the excellent collection of articles and essays, On Metaphor, edited by Sheldon Sacks (University of Chicago Press, Chicago: 1978), which includes contributions by Ted Cohen ("Metaphor and the Cultivation of Intimacy"), Paul de Man ("The Epistemology of Metaphor"), Donald Davidson ("What Metaphors Mean"), Wayne C. Booth ("Metaphor as Rhetoric"), W. V. Quine ("A Postscript on Metaphor"), Nelson Goodman ("Metaphor as Moonlighting") and Max Black ("How Metaphors Work"), among others; and Michael Walzer, "On the Role of Symbolism in Political Thought," Political Science Quarterly v. 82 #2 (June 1967) pp. 191-205.

6. C. Day Lewis, The Poetic Image (London, 1947), p. 72.

7. This is a trend that is reaching its fullest literary flower in the pages of the New Yorker, where the pattern of metaphor in most of the short fiction is incestuous in the way it fails to connect with anything beyond the realm of human artifact.

7. Continued
In the stories of Ann Beattie we learn about characters primarily through the brand-name products they own, use, or consume, and in one of Frederick Barhthelme's stories we are treated to analogies such as the one that likens a characer's thin arms to the cardboard tubes upon which paper towels are rolled.

8. There is a conundrum here similar to others that mark the relationship between individuals and collectivities. An individual instance of metaphor must take the system of associated commonplaces as given, but a particularly apt or vivid metaphor can change the images and qualities associated with its vehicle. In much the same way, individual beliefs and behavior affect and are affected by social institutions and relations.

9. Bill J. Harrell, "The Social Basis of Root Metaphor: an Application to _Apocalypse Now_ and _Heart of Darkness_," _Journal of Mind and Behavior_, Vol 3 #3, pp. 221-240; p. 221.

10. This is not a fair comparison, for the difference here is between a totemic relationship and a metaphoric relationship, not two instances of metaphor. Totemic relationships are not instances of metaphor, for the tension of comparison is lost between two entities that are identical. The difference between metaphor and totem is the difference between philosophy and myth, and if "the emergence of the theater of reason --that is, of philosophy...--may have been more a symptom of [a] decline than a source of rejuvenation" (John Rodman, "The Other Side of Ecology in Ancient Greece: Comments on Hughes," _Inquiry_, vol. 19 #1 [Spring 1976] pp. 108-112, p. 109), then metaphor, too is emblematic of a loss--and the phrase "entropy metaphor" contains yet another self-reflective resonance.

11. Otto Fenichel, paraphrased by Gregory Bateson in _Steps Toward an Ecology of Mind_ (Ballantine Books, New York: 1972), p. 139.

12. Bateson, p. 139.

13. Bateson, p. 140.

14. Bateson, p. 140.

15. Stephen Pepper, _World Hypotheses: A Study in Evidence_ (University of California Press, Berkeley: 1948), pp. 98-99, p. 79; see also the account of Pepper's four root metaphors in Berggren, p. 465.

16. Pepper, p. 91.

17. It needs to be made explicit here that this definition of root metaphor does not require that the language in which a root metaphor is expressed be expressly metaphoric, or that it contain any explicit reference to any of the possible vehicles of the root metaphor. As an example, let me point out that in the Introduction I suggested that we accept a definition of "the political" that sees it as comprising "every conceivable form of power, wherever it is found," while noting that one criticism that could be levelled against this definition is that it would require any movement for an equality of personal empowerment to accomplish a world-wide transcendence of politics. I further pointed out that this criticism was premised in a mechanistic interpretation of "power", and for that reason found it not compelling. Note that nowhere in the criticism does there appear any language that overtly likens politics to a mechanical process or perspective. The work of the root metaphor is accomplished through the single word "power", which has one meaning -- on "system of associated commonplaces" --in the conceptual vocabulary of mechanism, and quite a different meaning in the conceptual vocabularies of other root metaphors.

18. See Richard Hofstadter, "The Paranoid Style in American Politics," pp. 3-40 in <u>The Paranoid Style in American Politics and Other Essays</u> (Vintage Books/Random House, New York: 1967) for an interesting account of the world-ordering functions of essentially paranoid belief systems in the political arena. We will have more to say on this subject in chapter seven.

19. Pepper, p. 431.

20. The term "paradigm" was popularized by philospher and historian of science Thomas Kuhn in <u>The Structure of Scientific Revolutions</u> (University of Chicago Press, Chicago: 1970, 2nd Edition). See Margaret Masterman, "The Nature of a Paradigm," pp. 59-89 in Imre Lakatos and Alan Musgrave, eds., <u>Criticism and the Growth of Knowledge</u> (Cambridge University Press, Cambridge: 1970) for a discussion of the various meanings that Kuhn himself attaches to that term. See also Arthur Effron, "Introduction: Pepper's Continuing Value," <u>Paunch</u>, vol. 53-4, pp. 5-53; Andrew J. Reck, "Pepper and Recent Metaphilosophy," <u>Journal of Mind and Behavior</u> vol. 3, #3, pp. 207-216; and Stephen Pepper, "Metaphor in Philosophy," <u>Journal of Mind and Behavior</u> vol. 3, #3 pp. 197-205 for discussions of the relationship between Kuhn's work and Pepper's, and on the question of influence. "After reading Pepper's discussion of him in 'Metaphor and Philosophy,' Kuhn was unable to say whether he drew any direct influence from Pepper, though he grants the appropriateness of the question"--Efron, pp. 23-4.

21. Pepper admits as much on pp. 338-40 and p. 149 of World Hypotheses.

22. Pepper, World Hypotheses, p. 340.

23. Pepper draws a further distinction from this one, using the term data to describe the products of multiplicative corroboration and coining the term danda to refer to the products of structural corroboration. Thus, says Pepper, positivism is simply a prejudiced preference for data over danda. The chair analogy is from pp. 48-9 in World Hypotheses. Others, of course, have recognized the role of metaphor in scientific thought. See W. V. Quine, "A Postscript on Metaphor," loc. cit. (note 5, above); Douglass Berggren, pp. 471-2; Richard Olson, ed., Science as Metaphor (Wadsworth, Belmont California: 1971); Jacob Bronowski, Science and Human Values (Harper and Row, New York: 1965), especially p. 15. Gordon Patterson, in "Paradigms, Puzzles, and Root Metaphors: Georg Christoph Lichtenberg and the Exact Sciences" (Journal of Mind and Behavior, vol. 3, #3, pp. 275-87) claims Lichtenberg as an early (18th Century) appreciator of the role that metaphor plays in scientific theory and discovery.

24. Pepper, World Hypotheses, p. 122.

25. Pepper, World Hypotheses, pp. 180, 221-8, 310, 268-9. See also the summaries of these epistemologies given by Arthur N. Geddis in "Teaching: A Study in Evidence," Journal of Mind and Behavior, vol. 3 #4, pp. 363-373.

26. Pepper, World Hypotheses, p. 328.

27. Sheldon Wolin, Politics and Vision (Little, Brown and Co., Boston: 1960), p. 8.

28. Michael Walzer, "On the Role of Symbolism in Political Thought," Political Science Quarterly, vol. 82 #2 (June 1967) pp. 191-205, p. 195n.

29. Martin Landau, "The Use of Metaphor in Political Analysis," Social Research (Autumn, 1961) pp. 331-351. Landau discusses the shift in metaphoric styles, from mechanistic to organic, in American political analysis as it is manifest in the works of Woodrow Wilson (Constitutional Government in the United States [New York: 1908]) and Walter Lippmann (A Preface to Politics [New York: 1913]). Lippman clearly saw himself as effecting a shift in conceptual imagery; his brief against mechanism asserts that "we have, it seems, been seduced by a fictitious analogy." (p. 23)

30. Stephen G. Brush, The Temperature of History (Burt Franklin and Company, New York: 1978), p. 134.

Notes to Chapter Three

1. Thus, P. W. Bridgeman: "There can be no doubt, I think, that the average physicist is made a little uncomfortable by thermodynamics...the laws of thermodynamics have a different feel from most of the other laws of the physicist. There is something more palpably verbal about them...they smell more of their human origin." The Nature of Thermodynamics (Harvard University Press, Cambridge: 1943), p. 3. Nicholas Georgescu-Roegen speaks of the unidentified purists I mention in the title essay of Energy and Economic Myths (Pergamon Press, Elmsford, New York: 1976), p. 7; see also pp. 276-7 in his The Entropy Law and the Economic Process (Harvard University Press, Cambridge: 1971). The mottoes for this chapter come from Donald Rogers, "An Informal History of the First Law of Thermodynamics," Chemistry, December 1976, p. 14, and (the quotation from Morley) Irwin N. Hiebert, "The Use and Abuse of Thermodynamics in Religion," Daedalus 95: 1046-80, p. 1047.

2. Donald Cardwell touches briefly on the relationship between thermodynamics and an early nineteenth century energy crisis in From Watt to Clausius (Cornell University Press, Ithaca, New York: 1971), p. 190.

3. Sadi Carnot, Reflections on the Motive Power of Fire, collected (with other papers on the second law of thermodynamics) by E. Mendoza (Dover Publications, New York: 1960), p. 7.

4. See Donald Cardwell, "Some Factors in the Early Development of the Concepts of Power, Work, and Energy," British Journal for the History of Science, vol. 3 #11 (November, 1967), pp. 209-224, and Donald Rogers, "An Informal History of the First Law of Thermodynamics," loc. cit., pp. 11-15. One manifestation of the second law is to be found in the fact that motion is perfectly convertible into heat, but heat is only imperfectly convertible into motion. That is, in the former process it is possible to attain an efficiency of 100%--all motion converted into heat--but the converse is not true. Motion is counted as a higher, more valuable form of energy for this reason.

5. Mayer's story is worth recounting in somewhat greater detail for the background it gives to early nineteenth century physics, and for the morals one may draw from it. Mayer en-

5. Continued
ters the annals of physics through his role as a ship's surgeon on a journey to the south seas in 1840. He, like Darwin, took a great number of scientific books with him on the trip, reading them (one imagines) assiduously into the night. In the course of his duties he had cause to perform a bloodletting on one of the members of the crew, and was surprised to find the venous blood bright red, instead of bluish red as it is in colder climates. He knew that food is nutritional energy converted by the body into work; he knew, from reading Lavoisier, of oxygen and its role in combustion; and he knew that the presence of oxygen makes blood red. He concluded that something in northern climes was using up blood oxygen which was not used in the tropics; he reasoned correctly that in the tropics, the body needs less energy to maintain body temperature. Here was his first inkling of the first law of thermodynamics: food energy can be converted into heat, or work, suggesting that there is some equivalence between the two. On the voyage home, he wrote a paper on the subject.

Upon his return, Mayer sent the paper to the most prestigious physics journal in Germany, only to have it refused as unreadable nonsense. His lack of background in physics showed up as an inability to communicate in terms that physicists would understand; he consistently used the word "force," for example, when he meant energy, even though the former term had been rigorously defined by Newton some 140 years previously. Finally, the paper was published in 1842 in _Annalen der Chemie und Pharmacie_, where it received no notice by physicists.

At his own expense Mayer printed pamphlets containing his ideas, which were ridiculed or ignored; he became a man obsessed with broadcasting his idea. (One story, perhaps apocryphal, has Mayer succeeding in gaining an audience with the director of a physics institute. After hearing his ideas, the director dismissed them, pointing out that if they were true, one would be able to raise the temperature of water by merely shaking it. Mayer bolted from the room, and the director thought no more of the matter. Several weeks later, however, Mayer returned, proclaiming "It's true!," as if the conversation had scarcely been interrupted, much to the puzzlement of the director. Unfortunately, Mayer's apparatus was operating at the limits of its reliability--the temperature increase obtainable in shaking water is real, but slight--and the director remained skeptical. It remained for Joule to establish the mechanical equivalent of heat in this fashion, with improved apparatus.) By 1850, Joule was attracting attention for ideas that Mayer had articulated or had in manuscript some ten years earlier; depressed, in 1851 Mayer tried to take his own life and failed. His family committed him to an insane asylum, where no doubt his claim to have discovered a fundamental law

5. Continued
of nature received no greater notice. Upon his release, he immersed himself in gardening and gave up any hope of gaining recognition.
This was where matters stood until 1862, when John Tyndall gave a talk before a Royal Institution audience in London on the principle of conservation of energy. Tyndall had discovered Mayer's work and, perhaps because he was Irish and therefore had reason not to accept English claims of priority at face value, suggested that the principle had been first formulated by Mayer and that the German was being unjustly ignored. Joule took offense at this, and wrote that his claim could not be denied, for he had worked in ignorance of Mayer's very existence. With this, Tyndall agreed, and the matter might have ended there had not P. G. Tait entered the fray. With Kelvin (William Thomson, Lord Kelvin) he wrote an article for a popular journal in which the controversy was reopened, Mayer's claim rejected, and Tyndall's scientific abilities called into question. (Tait, a good friend of James Clerk Maxwell's, went on to create for himself the role of propagandist for British, nationalistic science, advancing the reputation of Kelvin at the expense of Clausius and writing texts--he was one of the first to do so--in which the work of British scientists, particularly Rumford and Davy, was blown all out of proportion.) Finally, however--and in spite of Tait--sanity and justice prevailed, and due honors came to Mayer for his priority, including the Copley medal in 1871, seven years before his death in 1878. See Cardwell, _From Watt to Clausius_, pp. 283-4 and 229-31; Rogers, pp. 14-5; E. E. A. McKenzie, _The Major Achievements of Science_ (Cambridge: 1960), p. 171; Max Jammer, "Energy," _Encyclopedia of Philosophy_ vol. 2 (MacMillan Publishing, New York: 1967) pp. 511-17, p. 514.

6. Cardwell, _From Watt to Clausius_, p. 209.

7. _Ibid._, p. 210.

8. _Ibid._

9. Carnot, p. 7.

10. Carnot, p. 28.

11. In the early 1700's Edmund Halley (1656-1742), the English astronomer and geophysicist, made a great contribution to the understanding of the hydrological cycle by experimenting on the rate of evaporation and suggesting that the circulation of water on the planet is a closed system. But in an era when no accurate rainfall data existed, when large parts of many watersheds remained unexplored or unmapped (and when the notion of a watershed itself scarcely existed), when little

11. Continued
was known about the capacity of aquifers to store rainfall and release it gradually into streams, the incontrovertible evidence of experience suggested that the flow of streams and rivers was not totally dependent on rainfall. Not until the early decades of the nineteenth century was the notion of the hydrological cycle as a closed system fully accepted. See Cardwell, From Watt to Clausius, pp. 8-10, p. 187.

12. Ibid., p. 201.

13. Carnot, p. 59.

14. Carnot, p. 4.

15. Rudolf Clausius, "On Several Convenient Forms of the Fundamental Equations of the Mechanical Theory of Heat," in The Mechanical Theory of Heat (London: 1867), pp. 327-65.

16. Quoted in Charles Coulston Gillispie, The Edge of Objectivity (Princeton University Press, Princeton, New Jersey: 1960), p. 399.

17. Boltzmann built on the work of James Clerk Maxwell, who was apparently led to conceive of gases as collections of tiny particles by the success of a student essay he had written, which argued that the rings of Saturn are stable because they are systems of distinct particles and not solids or fluids as had been thought. In 1859 (when Boltzmann was 15), Maxwell wrote a landmark paper in which he showed that information about the aggregate properties of a gas (density, pressure, etc.) could be obtained by calculating the most probable speeds of the molecules at a given temperature. "The paper presented, for the first time, a law of nature not absolute and without exception, but only statistical." Jeremy Campbell, Grammatical Man (Simon and Schuster, New York: 1982), p. 39. On Boltzmann's work, see also Mahadev Dutta, "A Hundred Years of Entropy," Physics Today (Jan. 1968) pp. 75-79, p. 77; Paul K. Feyerabend, "Ludwig Boltzmann," Encyclopedia of Philosophy vol. 1 (MacMillan Publishing, New York: 1967) pp. 334-7; Max Jammer, "Entropy," Dictionary of the History of Ideas Vol. III, Philip P. Weiner, editor-in-chief (Charles Scribners' Sons, New York: 1973), pp. 113-120, p. 115; C. J. Whitrow, "Entropy," Encyclopedia of Philosophy vol. 2, pp. 526-9. Nicholas Georgescu-Roegen gives a detailed account of Boltzmann's theories and their evolution under criticism in The Entropy Law and the Economic Process (p. 146 and following), and Barry Commoner offers a good lay introduction to the statistical nature of the entropy law (although he doesn't place it in its historical context) in The Poverty of Power (Bantam Books, New York: 1976), pp. 6-29. Much of Boltzmann's work remains untranslated.

18. Boltzmann, "The Second Law of Thermodynamics," in _Theoretical Physics and Philosophical Problems_, ed. by Brian McGuiness (D. Reidel Publishing Co., Boston: 1974), p. 20.

19. _Ibid._

20. Quoted in Lewis S. Feuer, _Einstein and the Generations of Science_ (Transaction Books, New Brunswick, New Jersey: 1982) p. 336.

21. Feuer gives a generally good, if a trifle psychologistic, account of the Machians' dissatisfaction with Boltzmann in "The Tragedy of Ludwig Boltzmann: A Case Study in the Consequences of Generational, Methodological Fanaticism," pp. 335-341 in _op. cit._ Feuer's account is particularly suggestive when it focusses on the imagery used by the various factions. One phenomenologist challenged Boltzmann's atomism by calling for a "direct experience" of nature, unmediated by mental constructs, in these words: "The rigor of science requires that we distinguish well the undraped figure of nature itself from the gay-colored vesture with which we clothe it at our pleasure." Boltzmann replied: "But I think the prediliction for nudity would be carried too far if we were to forego every hypothesis." Feuer discerns in this "imagery of maternal nudity" some hint of "the innermost source of the recurrent phenomenological motif in generational rebellions of young scientists," by which I _think_ he is suggesting that young scientists rebel against the received methodology of their disciplines out of unresolved Oedipal urges. (If he isn't suggesting this, he ought to write more clearly.) A more appropriate interpretation might locate the source of the nudist imagery in the same factors that gave rise to the cult of exersize, health, and fresh air in Germany that was popular at that time, and thus locate the conflict he describes more completely in a social and "generational" difference, rather than in individual psychology. Boltzmann had a well developed philosophy of science, and by its lights he remained skeptical of the phenomenologists' claims to be able to confront experience without the distorting filter of a conceptual apparatus. His reliance on critical dialogue grounded in competing models as the mechanism of science anticipates later developments by Kuhn (and Feyerabend himself); see Feyerabend, _op. cit._

22. Mach: Peter Alexander, "Ernst Mach," _Enclyclopedia of Philosophy_, vol. 5, pp. 115-119; Boltzmann's suicide: Feuer, p.339. Machians were "phenomenologists" in the older, pre-Husserl sense of the term: holders of the view that phenomenology--the purely descriptive study of phenomena--was the aim of science. See Alexander, _op. cit._, and Richard Shmitt, "Phenomenology," vol. 6 _Encyclopedia of Philosophy_, pp. 135-151, esp. p. 135.

23. James Clerk Maxwell, The Theory of Heat (Longmans, Green and Co., London: 1902), pp. 338-9. Maxwell first mentioned the demon in a letter to Tait in December, 1867, and made it clear later that he meant to suggest by his supposition of this "fanciful creature" that the second law was statistical, rather than mechanical, in nature. "Maxwell's views on the nature of the second law...were never developed [by him] into a systematic statistical mechanics, but they show how clearly he saw into the heart of the matter. He was insisting on the statistical character of the second law at a time when Rudolf Clausius and Ludwig Boltzmann were trying to show that it was a strictly mechanical theorem." Martin J. Klein, "Maxwell, His Demon, and the Second Law of Thermodynamics," American Scientist vol. 58 (1970), pp. 84-97, p. 85. Interestingly, Maxwell signed his letters to Tait and other intimates with the symbol "dp/dt," which is one half of an equation (dp/dt= JCM) that is a statement of the second law. (Klein, pp. 94-5)

24. W. Ehrenberg, "Maxwell's Demon," Scientific American vol. 217, #5 (Novermber, 1967), pp. 103-110, p. 106.

25. Ehrenberg, p. 109.

26. Doede Nauta Jr., The Meaning of Information (Mouton Press, The Hague: 1972), p. 19.

27. Warren Weaver, "Some Recent Contributions to the Mathematical Theory of Communication," pp. 1-28 in The Mathematical Theory of Communication by Claude Shannon and Warren Weaver (University of Illinois Press, Urbana, Illinois: 1949), p.13.

28. Weaver, pp. 8-9.

29. Norbert Weiner and a number of scientists from MIT and Bell Labs in New Jersey worked on an electrical sighting device for anti-aircraft guns. The problem was one of probability: an airplane cannot appear in the sky at random, but must fly a continuous course, and the gunner tries to guess where the plane will be by the time the shell arrives at its altitude. The American-designed "predictor," when it went into service in August 1944, helped to increase the ratio of V-2 rockets shot down from 10% to 50%. Campbell, pp. 25-6, p. 31.

30. Leon Brillouin, "Maxwell's Demon Cannot Operate--Information and Entropy I," Journal of Applied Physics vol. 22 (1951), pp. 334-43.

31. Ehrenberg, p. 109.

32. Martin J. Klein, "Thermodynamics in Einstein's Thought," Science 157: 509-516 (August, 1967), p. 509. Hereinafter, cited as Klein, Einstein article.

33. Klein, Einstein article, p. 510.

34. Einstein's paper on Brownian motion appeared in the *Annalen der Physik*, series 4, vol. 17, pp. 549-560. See also Ronald W. Clark, *Einstein: the Life and Times* (Avon Books, New York: 1971), pp. 89-90 and Albert Einstein and Leopold Infield, *The Evolution of Physics* (1938; Simon and Schuster, New York: 1966), pp. 58-60 for explication. Clark's characterization of Einstein's work is on p. 91, *op. cit*. Einstein's paper "On a Heuristic Viewpoint Concerning the Production and Transformation of Light" (vol. 17 of the *Annalen der Physik*) is commonly known as "the photoelectric effect paper" although that problem was not Einstein's central concern; he is addressing what he calls the "profound formal distinction" mentioned below in the text.

35. Klein, Einstein article, p. 512.

36. Clark, p. 95.

37. Klein, Einstein article, p. 512.

38. Einstein's discussion of these two types of theories is found in *Out of My Later Years* (Philosophical Library, New York: 1950), pp. 54-5.

39. Albert Einstein, "Autobiographical Notes," in *Albert Einstein: Philosopher Scientist*, P. A. Schilpp, ed. (Library of Living Philosophers, Evanston, Illinois: 1949), p. 32.

40. Klein, Einstein article, p. 515.

Notes to Chapter Four

1. Irwin N. Hiebart, "The Use and Abuse of Thermodynamics in Religion," _Daedalus_ 95: 1046-80 (Fall 1966), p. 1051.

2. _Ibid._

3. Arthur S. Eddington, _The Nature of the Physical World_ (Cambridge, 1928) pp. 73-5.

4. Fechner introduced to psychology the notion of conservation of psychic energy; the relevant work of his remains untranslated. See Frank L. Sulloway, _Freud: Biologist of the Mind_ (Basic Books, Inc. Publishers, New York: 1979), p. 66, and Sigmund Freud, _Beyond the Pleasure Principle_, in _Major Works of Freud_ (William Benton/Encyclopedia Brittanica, Inc., Chicago: 1952), p. 639 for reference to Fechner's work and its relationship to that of Freud. Herbart had, at the beginning of the nineteenth century, developed a dynamic theory of unconscious processes, in which he spoke of "repressed" ideas retaining their "force", which he hoped psychology would someday be able to measure; see Sulloway, p. 67. In 1893, Heinrich Sachs wrote a psychology text in which he discussed the "law of the constant quality of mental energy," which amounted to a preemption of Freud and Breuer's joint article on a similar topic; see Sulloway, p. 87; _The Origins of Psychoanalysis: Letters to Wilhelm Fleiss, Drafts, and Notes, 1887-1902_, by Sigmund Freud, edited by Marie Bonaparte, Anna Freud, and Ernst Kris, translated by Eric Mosbacher and James Strachey (Basic Books, New York: 1954), letter dated Nov. 29, 1895, p. 135; Sigmund Freud and Josef Breuer, "Preliminary Communication," in _Major Works_, p. 27; and Freud's article from the collaborative book with Breuer, "The Psycho-Therapy of Hysteria," pp. 59-81 in _Major Works_ (originally published in 1896). Freud credits Breuer with originating a distinction between "free" and "bound" psychic energy, and called it "the deepest insight we have gained up to the present into the nature of nervous energy," in _The Unconscious_ (_Major Works_, pp. 428-448) p. 437. Some think that the second law of thermodynamics lies behind Freud's concept of the death instinct, though others disagree; the lines of this debate are drawn by Sulloway, pp. 404-9. See also Judith B. Winter, "The Concept of Energy in Psychoanalytic Theory," _Inquiry_ 14: 138-147, which offers a survey of the idea of energy in Freud's work.

5. Hiebart, _op. cit._

6. For some time the second law of thermodynamics threatened to destroy the Darwinian theory of evolution -- not because the second law seemed to contradict a natural process that produced, through time, increasing complexity, but because calculations done by Kelvin in accordance with the second law indicated that the earth's crust had not maintained its stability long enough to provide evolution with the vast quantities of time that were necessary to its operation. See Sir William Thomson (Lord Kelvin), "The Doctrine of Uniformity in Geology Briefly Refuted," (1865) reprinted in _Popular Lectures and Addresses_ by Sir William Thomson, 1894, Vol. 2, pp. 6-9. Darwin recognized the force of the objection, and at times despaired of ever finding a way around it. "I have not as yet been able to digest the fundamental notion of the shortened age of the sun and earth," he wrote in 1871 to Wallace. (James Marchant, _Alfred Russel Wallace: Letters and Reminiscences_, New York: 1916, pp. 205-6.) Although the controversy was first joined in 1865, it continued for decades, and by the 1890's a new consensus had emerged concerning the age of earth, a consensus which took Kelvin's much reduced time scheme as compelling; see, for instance, W. J. Sollas, "The Age of the Earth," _Nature_, 1895, Vol. 51; Charles Walcott, "Geologic Time; As Indicated by the Sedimentary Rocks of North America," _The American Geologist_, 1895, Vol. 12; and Archibald Geikie, "Twenty-five Years of Geological Progress in Britain," _Nature_, 1895, Vol. 51. Each of these geologists accepted an age for the earth denominated in millions of years, with Geikie venturing the largest estimate at 100 million. This constrained time scheme pushed Darwin into contradictions in the last edition of his _Origin of Species_. Earlier editions had held that "organisms high in the scale, change more quickly than those that are low," and this language survived into the last edition (p. 256 of the Modern Library ed.), even though it contradicted the new language inserted to meet the thermodynamicist's objections: "The world at a very early period was subjected to more rapid and violent changes in its physical condition than those now occuring; and such changes would have tended to induce changes at a corresponding rate in the organisms which then existed." (_Ibid._, p. 253.) Kelvin's calculations are now seen to be mistaken; the earth is, according to current scientific belief, on the order of 4 or 5 billion years old. But Kelvin's calculations were essentially correct, given the information and knowledge he had; he did not know about the heat produced by radioactive decay (and could not have known: radium was discovered in 1905), which, when factored into the calculations, produced an age for the earth consistent with evolutionary theories. See the account of this controversy in Loren Eisley, _Darwin's Century_ (Doubleday and Company, Garden City, New York: 1958), pp. 233-253.

7. Brooks Adams, "Preface" to _The Law of Civilization and Decay_ (Alfred A. Knopf, New York: 1943), p. 57; and Brooks Adams, "The Heritage of Henry Adams," editor's introduction to _The Degradation of the Democratic Dogma_ (New York: 1919), pp. 87-90.

8. Brooks wrote: "If I live forever, I shall never forget that summer. Henry and I sat in the hot August evenings and talked endlessly of the panic and of our hopes and fears, and of my historical and economic theories, and so the season wore away amidst an excitement verging on revolution." "Heritage," p. 94.

9. Theodore Roosevelt's judgment, recorded in _The American Nation: A History of the United States_ by John A. Garraty (Harper and Row publishers, New York: 1966) p. 617.

10. See Frederick Jackson Turner, _The Frontier in American History_ (New York: 1920). Turner first presented his "frontier thesis in a lecture in 1893. For some, the answer was continued expansion; the Spanish-American War was fought in 1898.

11. See Samuel P. Hays, _Conservation and the Gospel of Efficiency: the Progressive Conservation Movement 1890-1920_ (Atheneum Press, New York: 1975).

12. Geoffrey Barraclough, _An Introduction to Contemporary History_ (Penguin Books, Middlesex, England: 1967), pp. 53, 46, 51, and 49.

13. Barraclough, p. 43.

14. Emile Durkheim, _Suicide: A Study in Sociology_, trans. by John A. Spaulding (The Free Press, New York: 1966), p. 246.

15. Durkheim, p. 252.

16. Barraclough, p. 55.

17. Garraty, p. 629.

18. Brooks Adams, "Heritage," p. 90.

19. "Heritage," p. 91.

20. _Law_, _passim_; direct quotation from Preface, p. 61.

21. _Law_, p. 306.

22. _Law_, p. 59.

23. From the "Introduction" to the Law by Charles A. Beard, pp. 3-53, p. 8, quoting a letter to Henry dated at Venice, June 30, 1894.

24. "If intellectual phenomena are evolved in regular sequence, history, like matter, must be governed by law....In support of such a conjecture, I venture to offer an hypothesis." Brooks Adams, p. 59 of the Law.

25. Law, p. 59.

26. Law, pp. 59-60.

27. The main problem is, of course, the one mentioned in the text -- the lack of any measure of the efficiency with which the energy is used. The idea that there is an equation to be found between levels of energy use and level of development or civilization is discussed and challenged by George Basalla, "The Fallacy of the Energy-Civilization Equation," a paper published as part of Symposium: A Report from the Edison Electric Institute, a flyer inserted into issues of Harper's in 1979.

28. Law, p. 60.

29. "Heritage," pp. 90-91. We should note but not accept as definitive Henry's demurrer; madness, after all, has been known to run in families.

30. Some thought will show that the definition of root metaphor presented in chapter two now presents us with a problem: if root metaphors are patterns of imagery in the thought and rhetoric of a culture, who first originates them, and can that originator be said to be employing root metaphor if he or she does so alone? Is the first use of a root metaphor, or the use of a root metaphor that is not widely shared by others, to be dismissed as being the product of a crank or lunatic? It seems too pat an answer to remark simply that history indicates that the answer to this last question is "yes". These questions are the questions that plague any example of the sociological school of epistemology, and we will have occasion to reflect upon them further in chapters seven and eight.

31. See, for instance, those recounted by Hiebart in op. cit.

32. In his autobiography, Ostwald described his first encounter with the idea that would shape his life and work in language that is appropriate to revelation: it was a "lightninglike illumination," a "pentecostal inspiration," accompanied by "an almost physical sensation in my brain." He had grappled

32. Continued
with the problem of matter and energy, and had been satisfied to accept a parallelism between the two; now, in a moment of insight, he saw that energy was all; he "recognized that everything we sensually experience can be reduced to energy relationships between our sense organs and the world around us." (Autobiography, II, p. 158 ff.; quoted by Eduard Farber in "Wilhelm Ostwald," pp. 1020-30 in Great Chemists ed. by Eduard Farber [Interscience Publishers, New York: 1961], p. 1025.) This illumination of Ostwald's took place in 1890, confirming that the decade from 1890 to 1900 was a time in which thermodynamic ideas were enjoying an unusual popularity.

33. Thus, "By every transformation of this kind [in which 'native energy' is transformed into 'forms...suited directly to the needs of mankind'] one part of the native energy is converted by the equalization of intensity...into the unusable form of latent energy [or heat], and only a certain fraction of the original native energy serves its purpose. Every machine, every process, in fact every intelligent person who improves this coefficient of transformation is valuable, and the greater the improvement and the more important for mankind the kind of energy upon which the improvement is devoted, the more valuable he is." Ostwald, "The Modern Theory of Energetics," The Monist, XVII #4 (Oct. 1907), pp. 481-515, p. 514.

34. Ostwald, "Efficiency," The Independent, Vol. 71 (Oct. 19, 1911), pp. 867-71, p. 871.

35. Ostwald knew that the law of entropy was behind his energetic imperative; see "The Modern Theory of Energetics," loc. cit., p. 507, where he discusses the "second principle of energetics." For the grounds upon which Ostwald turned his energetics into a social and political doctrine, see "A Theory of Happiness," International Quarterly, vol. 11 (April-July 1905), pp. 316-326; he there turns energism into a psuedo-utilitarianism by accepting happiness as the highest moral value and by proclaiming that "the lasting sensation of happiness is achieved through a successful exercise of energy," p. 316. Ostwald was led by his Energism to advocate eugenics policies, to abhor war, to promote Esperanto as an international auxillary language, and to envision a world utopia run by technocrats pursuing the efficient use of resources for the (vaguely defined) good of all. He promoted these ends through the Monist Alliance (which he served as president for a time) and his own organization, "The Bridge", which was to bring together scientists from different countries in the pursuit of scientific and social efficiency. See Niles R. Holt, "A Note on Wilhelm Ostwald's Energism," Isis 61: 386-9 (Fall 1970) and Niles R. Holt, "Wilhelm

35. Continued
Ostwald's 'The Bridge'," British Journal for the History of Science, 10: 146-50 (1977). World War I put an end to "The Bridge" as nationalism among scientists prevailed over the internationalism that Ostwald hoped to promote; Ostwald himself gave half-hearted support to the German war effort (but not enough to prevent his being deposed as president of the Monist Alliance by his more nationalist colleagues) while maintaining his objection to war in general as a violation of energist principles. After the war he ceased all work on energism and the agenda it implied, devoting the final twenty years of his life to a study of colors--although he refused to repudiate energism in the autobiography he wrote in the 1920s. "It was clear, however, that at the close of his career Ostwald had abandoned his earlier views of Energism as a unitary scientific monism and as a scientific creed for the solution of social and political problems." --Holt, "Note on Energism," p. 389.

36. Law, p. 60.

37. As such it stands as the premier text in a tradition that is still with us today: Howard T. Odum's Environment, Power, and Society (Wiley Interscience, 1971), for instance, is a more recent, less historical and less literary attempt to cultivate some of the same ground, as is the work of a new school of economic anthropologists who look to energy relations as the primary determinants of social structures, institutions, and relations.

38. "It anticipated by many years several central contentions put forward in Oswald Spengler's The Decline of the West, and indeed the whole spirit of this German work, especially its pessimism in respect of the Enlightenment, Progress, and Civilization. On this ground alone Brooks Adams' treatise ...is entitled to rank among the permanent classics of American thought." Beard, "Introduction," pp. 3-4.

39. As Nicholas Georgescu-Roegen did, in passing; see chapter six.

40. Brooks Adams, Law, p. 198.

41. Law, p. 300.

42. Law, p. 300.

43. Law, p. 301.

44. Law, p. 306.

45. Law, p. 210

Notes to Chapter Five

1. See Robert Nisbet, History of the Idea of Progress (New York: Basic Books, Inc., Publishers, 1980), pp. 318-323.

2. Henry Adams, "The Rule of Phase Applied to History," in The Degradation of the Democratic Dogma (New York: Peter Smith and the MacMillan Company, 1919), p. 308; the earlier phrase is a chapter title from William H. Jordy, Henry Adams, Scientific Hitorian (University of Yale Press, New Haven: 1952).

3. Brooks Adams, "The Heritage of Henry Adams," editor's introduction to The Degradation of the Democratic Dogma (New York: 1919), pp. 2, 3.

4. Letter of November 21, 1862, in A Cycle of Adams Letters, Worthington Chauncey Ford, ed. (Boston and New York: Houghton Mifflin, 1920; hereinafter, Cycle), Volume I p. 195. Compare what Adams says about the origin of this dualism as a habit of mind in his Education: as a boy, he spent winters in Boston and summers in Quincy. "Winter and summer, then, were two hostile lives, and bred two separate natures. Winter was always the effort to live; summer was tropical license....The bearing of the two seasons on the education of Henry Adams was...the most decisive force he ever knew; it ran through life, and made the division between its perplexing, warring irreconcilable problems, irreducible opposites, with growing emphasis to the last year of study. From earliest childhood the boy was accustomed to feel that, for him, life was double." The Education of Henry Adams, ed. with an introduction by Ernest Samuels (Boston: Houghton Mifflin Company, 1973), p. 9.

5. Jordy, Henry Adams: Scientific Historian, p. 121; cites a a letter dated November 25, 1877, in Worthington Chauncey Ford, ed., The Letters of Henry Adams, Volume I (1858-91) (Boston and New York: Houghton Mifflin, 1930). This latter work and its companion volume are hereinafter cited as Letters I and II.

6. Patrick Wolfe, "The Revealing Fiction of Henry Adams," New England Quarterly XLIX (49), #3 (Sept. 1976), p. 425n.

7. See Education, p. 300.

8. Jordy, pp. 38-41, gives an account of the election, Adams' position, and his disappointment.

9. Jordy, p. 41: "Probably he could have retained his post had he mended his ways; but the fascination of editorship had staled with its drudgery, especially with the prospect of an end to crusading -- and, after all, really no cause for which to crusade! ....Further work along the line of what he had once fancied as his career demanded a new start with less chance of success than before. Only the hardiest personality could have started again...."

10. See Brooks Adams, "Heritage," for his thoughts on the decline of the Adams family, which he saw as a failure to adapt to changing circumstances.

11. Adams was elected in absentia, and never attended a meeting.

12. "Power," Adams wrote in the Education, "is poison." p. 418. Compare Education, pp. 364f., on the evils and duties of public office; see also Adams' advice to Henry Cabot Lodge upon the latter's electoral defeat in 1881: "politics deteriorate the moral tone of everyone who mixes in them.... The moment is one for you to stop and think [about your choice of a career in politics]." Letters, I, p. 33.

13. Jordy, p. 258, and Samuels, p. 335-6, perpetrate this psychoanalytic reading of Adams' pessimism, though Samuels' interpretation is kept in perspective.

14. Henry Kariel, "The Limits of Social Science: Henry Adams' Quest for Order," American Political Science Review, Vol. 50 #4 (Dec. 1956), p. 1076. The judgment that Adams was a man who knew what he was about -- that is, who could see the emotional and psychological motives that affected his life -- is born out by the relationship between his life and the lives he portrays in the two novels he wrote: in Esther and Democracy, Adams seems to have foretold the events of his life, specifically the tragic death of his wife by her own hand. Ernest Samuels says, of the novel Esther: "In so closely transferring Marian's problem" -- she was deeply, unhealthily attached to her father -- "to fiction Adams seemed to be trying to work out by artistic insight the question that they would inevitably have to face when Marian's ailing father should die." (see Henry Adams: The Middle Years, p. 249.) Clarence King, perhaps Adams' closest friend, told John Hay that Adams had exposed much about Marian's relationship to her father in that novel (see ibid., p. 225); when King first read Esther he reportedly objected to the evasive ending and suggested that a more realistic conclusion would have the heroine commit suicide. Adams agreed, saying "Certainly she would, but I could not suggest it." (Ibid., p. 256.) See also Elizabeth Stevenson, Henry Adams (New York: 1956), p. 179, 182; J. C. Levenson, The Mind and Art of Henry Adams (Boston: 1957), p. 204; Wolfe, pp. 400-1; and Marian Adams, The Letters of Mrs. Henry Adams, Ward Thoron, ed. (Boston, 1936) pp. 41, 51.

15. Jordy, for instance; see pp. 12-13.

16. The Education is "pseudo-autobiography," for Adams never intended it as an autobiography and never called it that. When it appeared publicly in the year of his death, however, it bore that descriptive subtitle -- an error committed by his publisher. If the volume is autobiography, the omission of any reference to his marriage and his wife's death is almost unexcusable, unless we are willing to forgive him a lack of courage and to grant him what would, under the circumstances, be a paradoxical desire for privacy.

17. Education, p. 287. Wolfe asserts that "the death of his wife and the reasons for it were essentially responsible for the destruction of what he had told Gaskell...was his 'great faith in this country' and the future," p. 425. But then, one discovers in Wolfe's note to this, his concluding paragraph, the cavilling of a worried academic; having made a bold statement, Wolfe immediately qualifies it by attesting in the fine print that "This paragraph is not meant to imply that Adams' pessimism and determinism sprang from the tragedy of his wife's death"--which is exactly what he has imelied. Wolfe goes on to note that Adams had always had a pessimistic cast of mind, and offers the more temperate observation that, in the absence of Marian's moderating influence, Henry's pessimism became more cynical, bitter, and misanthropic. This more cautious formulation of his thesis brings Wolfe into line with Samuels, who found that the presence of his wife "used to subdue his violent tirades against the inadequacies of the human race to mere 'grumblings.'" Samuels, Middle Years, p. 323.

18. The rather complicated citations for this sentence are as follows: Robert Spiller describes Henry Adams' transition in his article, "Henry Adams," in Literary History of the United States, R. Spiller, W. Thorp, T. Johnson, H. Canby, eds. (New York: MacMillan, 1948), Vol. I, pp. 1080-1102, p. 1097; for Adams on the "lessons...that...warp the mind," see Education, p. 108; Adams describes himself as "absurdly in love," letter to Gaskell cited in Spiller, p. 1089; Spiller on the riddle of life, p. 1091; and Adams' description of his sister's death, Education, p. 287.

19. Brooks, with what appears to have been a characteristic generosity toward his brother, credits his Law of Civilization and Decay to Henry: "But for you I never should have printed it. Most of what has attracted attention has been the result of your criticism. The form is, I think, almost wholly yours...." (Letter to Henry Adams, July 5, 1899; cited in the "Introduction" to the Law by Charles A. Beard, p. 23.) But Henry made it clear that the work was not his;

19. Continued

not in conception, design, nor theory, nor even much in execution, though it was in this latter area that he gave Brooks most of his advice. When Brooks offered to dedicate the work to Henry, he demurred, pointing out that such a gesture would give critics and the reading public the wrong idea concerning the guiding intellect behind the work. "The book," he wrote his brother, "is wholly, absolutely, and exclusively yours. Not a thought in it has any parentage of mine." (Letters, II, p. 70.) Given that the two brothers could not agree on an apportionment of credit for the work, it is unsurprising that there is no agreement among historians, biographers and scholars on this subject. Beard, in his introduction to Brooks' Law, argues for an unacknowledged debt on Henry's part to his brother's work, but does so in such gentle tones that it is difficult to deny his position. "What Henry Adams would have done after 1893 if he had not had this experience with Brooks' work...no one can determine. It is a fact, however, that the flowering of Henry's interest in the theory of history -- the grand course of civilization -- came after, not before, that extraordinary experience with his brother's bold, powerful, and comprehensive effort to grapple with the secret of history. And a comparison of Henry's writings before 1893 with his writings after that year shows that during the period 1893-1899 he acquired certain fundamental conceptions of history, explicit in the Law, which subsequently bulked large in his historical thought and writing....By 1893 Brooks Adams, as an independent thinker, had struck out on lines which Henry was to explore on his own account in a similar spirit; and Henry Adams, aware of an indebtedness to Brooks, later applied, altered, and amplified theories of history which the two brothers had long and zealously discussed.

"But I refrain from attempting an apportionment and valuation of the influences which Brooks and Henry exerted on each other's thought, knowing full well that, in such cases of intellectual cooperation, this is a task beyond the powers of the human mind." Beard, pp. 28-9. Others have misrepresented Beard's argument, which is based on a careful collation of marginalia made in the various editions by Henry, and on a thorough knowledge of the work and correspondence of the two brothers; see Jordy (p. 132n), who feels that Beard credits Brooks with too much influence on Henry's thought.

20. Actually, Henry was engaged in writing a work at the time of his visit with Brooks. Published in a very small edition (probably no more than ten copies) in late 1893, the Memoirs of Maura Taaroa, Last Queen of Tahiti was the result of a visit to Tahiti that Adams had made in the winter and spring of 1890-91. Since Maura Taaroa could neither read nor write, the numerous allusions to western literature in the work indicate that there is more of Adams' voice in it than the first-person narrative would otherwise suggest. The book is a skillfull blending of geneology and background material drawn from the rich oral tradition of the island; interest in ancestry on the island had been stimulated at the time of Adams' visit by the French Administration's attempt to create written records to resolve land title and royal pension issues. Samuels finds the work to be a "parable of the decline of the west," and notes that the story of the royal family's decline from power would have had special poignancy for Adams; see Samuels, Major Phase, pp. 44-47 and 99-110. Spiller points out that with this book "Adams' work as an historian came to an end. His work as [an] artist and philosopher had scarcely begun." (p. 1088)

21. "The Tendency of History," pp. 125-133 in Degradation, p. 127; p. 130.

22. Jordy, p. 130.

23. The novice historian was Sarah Hewitt; see Jordy, p. 56.

24. See Education, p. 382.

25. Henry Adams, "Count Edward de Crillon," American Historical Review, 1 (1895), pp. 51-69; p. 51.

26. Education, p. 434. Compare: "All opinion founded on fact must be error, because the facts can never be complete, and their relations must be infinite," Education, p. 410.

27. See Letters, II, p. 119 concerning Adams' confusion about history at this time.

28. Education, pp. 434-5. Adams thought of his History as a "fixed and documented starting point" for the study of American history (Jordy, p. 16; cites letter of October 6, 1899 in Cater, p. 480), and said that he and Nicolay and Hay

28. Continued
(whose Life of Lincoln came out at the same time as his History) "had written nearly all the American history there was to write. The intermediate period needed intermediate treatment...." (Education, p. 323) The statements underscore Adams' penchant for conceiving of history as relation, as a movement between points of fixity that the historian articulates. For Adams the historian's job was also to predict the future, to "triangulate from the widest possible base to the furthest point he [sic] thinks he can see," Education, p. 395. Perhaps the width of Adams' base (the period from 1300 to 1900) accounts for his predictive successes (see note 52).

29. Samuels, Major Phase, p. 293.

30. Adams, Mont-Saint-Michel and Chartres (New York: Mentor/New American Library), p. 314.

31. Samuels, Major Phase, p. 293.

32. See Chartres, p. 17; p. 143.

33. Chartres, p. 296-7.

34. Samuels says, "The statistics on the production of coal and iron production [sic] became almost as much of an obsession as those on foreign trade," Major Phase p. 314. See Henry's letter to Elizabeth Cameron in Letters, II, p. 402, March 22, 1903: "We can never compete with Asia, and Chinese coal and labor, organized by a Siberian system. In tht event I allow till 1950 to run our race out." See also Education, p. 415: "Throughout northern Germany, Russia was felt even more powerfully than France. [But] In 1901, Russia had vanished, and not even France was felt; hardly England or America. Coal alone was felt...and the stamp was the same as that of Birmingham and Pittsburgh. The Rhine produced the same power, and the power produced the same people -- the same mind -- the same impulse."

35. Education, p. 489.

36. Education, p. 380. Adams had overlooked the dynamos at the Chicago Exhibition of 1893; preoccupied with Brooks' economic theories, which led him towards financial affairs and statistics on trade, he was slow to grasp the meaning of the new form of power. Dynamos had been in existence since Faraday's first experimental model in 1831; Samuels suggests that Henry's "discovery" of them in 1900, and the importance he then attached to them, was another instance of his projection: "Feeling a new epoch open in his thinking, he assumed a new epoch opening in the movement of the world." Major Phase, p. 232.

37. Education, p. 421. Adams uses the gender-specific language advisedly; he is well aware that men bear primary responsibility for the industrial and technological revolutions, and that women had historically been denied access to or participation in power. He believed that the feminine intellect was fundamentally different from the masculine mind (and he valued it more highly). Whether this belief would mark him as sexist is, as I understand it, currently a matter of debate within the feminist movement. There is a fine line, sometimes indiscernible to men, that separates the work of those who identify, celebrate, and strengthen the uniquely feminine, and the work of those who romanticize or denigrate the feminine mind by attributing to it exactly the same qualities as those who celebrate etc.

38. Education, p. 457-6. There is a confusion of images here in the idea of entropy being a decline into centralization, a confusion that stems in part from Adams' essentially artistic purpose and in part from the ambiguity of the idea of entropy itself. Society, to Adams, seemed to be slipping into disorder; this process can be compared to an entropic process without doing the idea any injustice. But to hold that such a disorder is manifest as an increasing centralization supported by an unprecedented use of fossil fuels seems to stretch the idea of entropy beyond recognition. The partisan of technological progress could just as easily --and perhaps with greater warrant from the second law -- maintain that society was becoming more ordered through massive use of fossil fuels, for energy maintains order in the face of the depredations of the entropy law. But Adams was not concerned to do justice to the law of entropy; he sought a powerful image, one with the weight of scientific authority behind it, through which to communicate his vision. And, as it turns out, the entropy law itself is ambiguous on this issue. See, for instance, Roger Lewis, "A Downward Slope to Greater Diversity" (Science, 217: 1239-40; 24 September 1982) which reports the work of two biologists who argue that "increasing species diversity is an inevitable consequence, not an apparent violation" of the second law; contrast that with the "traditional" interpretation which finds that evolution is an apparent anomoly to be explained only by reference to the massive infusions of energy provided to earth and its ecosystems by the sun.

39. Education, p. 431.

40. Education, p. 458. Henry, unlike his brother Brooks, makes explicit reference to the idea of entropy; see "A Letter to American Teachers of History," in The Degradation of the Democratic Dogma (Peter Smith, New York: 1919), pp. 140-143. Adams contrasts the modern conception of the universe suggested by entropy, with its grounding in male thought, with that of the middle ages, which he found to be ruled by the

40. Continued
feminine principle: "...she could not provide protection against the forces of nature. She did not think of her universe as a raft to which the limpets stuck for life in the surge of a supersensual chaos; she conceived herself and her family as the centre and flower of an ordered universe which she knew to be unity because she had made it after the image of her own fecundity ...." Education, p. 459.

41. Education, p. 451.

42. The dig at pragmatism is in Education, p. 457.

43. A. d'Abro, The Decline of Mechanism (New York: Van Nostrand, 1939) esp. chapter xxi for a discussion of Gibbs. See also Alexander Findlay, The Phase Rule and Its Application (London: Longmans, Green, 1906) chaps. i-iv.

44. Jordy, p. 170.

45. "The Rule of Phase Applied to History," pp. 267-311 in Degradation, p. 308. In an otherwise wrong-headed account of Adams' theory of history (see note 51, below), Roy F. Nichols gives a good sense of what the Ethereal Phase might be. He finds that recent (as of 1935) development in science "breaks down the old conception of an observable universe of visible proportions and brings us to the point where scientists declare that only through symbols and calculations of mathematics can we know anything of the microcosmos and macrocosmos. If we attempt to formulate physical concepts in non-mathematical and anthropomorphic terms, we destroy their purity. In other words, reason has gone beyond imagination. Mathematical symbols, or Henry Adams's ethereal or final phase of thought, are the intellectual dominants." "The Dynamic Interpretation of History," The New England Quarterly (June 1935, pp. 163-178), p. 170.

46. "Phase," p. 308.

47. "Phase," p. 308.

48. Adams' critical reader was Henry Bumstead, a mathematical physicist at Yale and a pupil of Willard Gibbs. On his comments and criticisms see Cater, pp. 646ff., 650n., and Jordy, p. 152.

49. Jordy, p. 170.

50. Letters, II, p. 531.

51. The first group of critics include Jordy; Roger Shumate (in "The Political Philosophy of Henry Adams," American Political Science Review, Vol. 28 (1934), pp. 599-610, esp. p. 610), who finds that we "must respect his efforts to make a science of history," even though Adams "did not select his scientific data impartially" (p. 609) and made a "one-sided use" of science; and Roy F. Nichols, who approves the call for a science of history, but believes that Adams' foundation has been made obsolete, for the promise of "unlimited power with almost no effort" means that "The second law of thermodynamics has lost its terror." (p. 171). James Truslow Adams, in "Henry Adams and the New Physics," (The Yale Review, Vol. 19 # 2, Dec. 1929, pp. 283-302) proposes the pragmatic test of Adams' theories, and finds that his prediction of a new phase of thought has been proven true by the development of the general theory of relativity, and his prediction of the reaching of the "limits of thought" is validated by Heisenberg's indeterminancy principle--all this, despite Adams' handicap of having had "too little data." (pp. 293, 294, 299) To be fair, these authors wrote before an edition of Adams' letters was generally available; critics such as James Stone ("Henry Adams's Philosophy of History," New England Quarterly, vol. XIV [1941], pp. 538-548) and Charles I. Glicksberg ("Henry Adams and the Repudiation of Science," Scientific Monthly, Vol. 64 [1947] pp. 63-71), who had access to Adams' letters, do a much better job of representing Adams' thoughts on science and its relevance to history.

52. In a particularly forced passage, Nichols writes of Adams' death "on an anxious day in March, 1918, when the great German offensive seemed about to carry Adams's theory to a perfect climax." (p. 168) Nichols, as well as James Truslow Adams, connects the "ethereal" stage with recent developments in physics, especially Einstein's general theory of relativity, and if by that word Adams meant a increased degree of abstraction and use of mathematics as the language of physical theory, they may have a point. Adams can be said to have predicted the atomic bomb only in the most general way: he did foresee the awesome destructive power science was likely to bring about ("Some day science may have the existence of mankind in its power, and the human race commit suicide by blowing up the world"--from a letter cited in Glicksberg, p. 64)--but did not connect that insight to Einstein's equation between matter and energy. Nor could he have: the letter cited was written in 1862, a good half-century before Einstein's theory (and well before Adams developed his theory of history, which tends to undercut its value as a prediction based on a "scientific" theory). Other predictions or perspectives make Adams seem prescient: the tendency toward homogeneity of culture in an industrial age, the decline of law as "theory or a priori principle" and the consequent diplacement of morality

52. Continued
by police as the force guiding individual behavior (see Cater, pp. 558-9), and the crisis of faith resulting from the rise of scientism are all early anticipations of modern perspectives. Kariel sees in Adams a proto-nihilist, or proto-existentialist whose response to a lack of absolutes in the chaos of reality was to find his point of fixity in the workings of the mind and the dignity, integrity, and artistry with which he undertook his philosophical and scholarly quest.

53. "A Letter to American Teachers of History," pp. 137-263 in Degradation, p. 132.

54. Again, Jordy, p. 131.

55. "Tendency," p. 126.

56. Neither should we discount Adams' penchant for controversy in explaining why he based his theory of history on dubious science. He once went so far as to insert, in a review of Lyell's Geology (one of his earliest appearances in print), "a sentence... intended to provoke correction," and was disappointed when Lyell, who read the review, let it pass. Education, p. 227.

57. For the glacier imagery, see the History, 9, p. 225, and the "Rule," p. 281; Adams mentions the comet in Education, pp. 489 and 478, and elaborates it in "Phase," pp. 300-03.

58. Education, p. 339.

59. Letters, II, p. 178.

60. "Tendency," p. 130.

61. See the ominous rumblings in the "Tendency," p. 133 concerning "the most powerful organizations the world has ever known for the suppression of [hostile] influences."

62. This provides us with an interesting interpretation of the continual and necessary tension between church and state. That tension revolves around the difference in the belief about the ultimate locus of the human perception of order. Religion finds order to be a primary product of mind -- either, in its animistic form, because the sense of order is created in the primary processes of mind, or, in its pantheistic form, because order inheres in the universe and primary processes of mind "merely" reflect it. The claims of the state are advanced by those who grant primacy to politics -- those who find order to be the product of human will. Monotheism is merely an awkward compromise: because of its reliance on a Supreme Authority, it is a political metaphysic projected into religious terms and categories.

Notes to Chapter Six

1. A. E. E. McKenzie, The Major Achievements of Science (Cambridge University Press, London: 1960), pp. 163-64.

2. Nicholas Georgescu-Roegen, "Energy and Economic Myths," in his book of the same name (Pergamon Press, New York: 1976), p. 9. Hereinafter this book, a collection of his articles, will be cited as E&EM.

3. If "the Entropy Law is the most economic...of natural laws," (Nicholas Georgescu-Roegen, "Energy and Economic Myths," pp. 8-9), then Gresham's Law is the most thermodynamic of economic laws. Thomas Gresham is credited with offering the world the insight that "bad money drives out good" -- that, other things being equal, debased or inflated money will remain in circulation while people will choose to hold their monetary balances in uninflated, undebased, or otherwise unadulterated forms -- though he never stated it quite so succinctly. (See Roy L. Garis, Principles of Money, Credit, and Banking [Macmillan Company, New York: 1934], pp. 69-70, for a citation of the passage in a letter to Queen Elizabeth upon which Gresham's reputation depends.) "Because of Gresham's prominence [as founder of the Royal Exchange and a well-known goldsmith] the principle that cheaper money drives out dearer money was given his name," (Hiram L. Jome, Principles of Money and Banking, Richard D. Irwin, Inc., Homewood, Illinois: 1957, p. 39) even though the principle had been known to the Greeks: it finds mention in Aristophanes' The Frogs.

   Like the entropy law, Gresham's Law has found widespread use as a metaphor for processes of decline. I myself have heard such formulations as "bad restaurants drive out good" (offered in explanation of the popularity of fast-food franchise operations), "bad television drives out good," and "bad newspapers drive out good." And we have uses such as this, by an economist: "There are many reasons for the decline in levels of public behavior....[One] is the displacement of traditional values by commercial ones. A Gresham's Law seems to operate as effectively in the world of moral values as in that of economic values; and the bad currency here strikes me as the steady insinuation of advertising mush into the vocabulary and communication of our society. ...[Advertising jingles] are instances of a process that empties communication of its content, that substitutes reflex for creative spontenaity, that destroys credence in the written or spoken word." Robert L. Heilbroner, "The Demand for the Supply Side," New York Review of Books, June 11, 1981, pp. 37-41, p. 40.

4. Henry William Spiegal, The Growth of Economic Thought, (Duke University Press, Durham, North Carolina: 1983) Chapter 8, "The Rise of Physiocratic Thought," pp. 170-200, p. 182.

5. M. Beer, An Inquiry into Physiocracy (Russell and Russell, Inc., New York: 1966), pp. 100-104.

6. Spiegal, p. 198.

7. John Kenneth Galbraith, The Age of Uncertainty (Houghton Mifflin Company, Boston: 1977), p. 17.

8. Mark Blaug, Economic Theory in Retrospect (Cambridge University Press, Cambridge: 3rd ed., 1978), p. 25. The physiocrats are treated in a chapter on "Pre-Adamite [sic] Economics."

9. John Kenneth Galbraith notes wryly that a fundamental tenet of the physiocrats -- the importance of agriculture as the source of all wealth -- can still be heard today by politicians in the hustings; he confesses to having written speeches like that himself when he was employed as a research director by the American Farm Bureau Federation. Galbraith, p. 18. See also Spiegel for a classic illustration of Kuhn's notion that each discipline revises its history to suit the needs of the paradigm of the moment.

10. Spiegel, p. 185.

11. Francois Quesnay, Ouvres, p. 337, p. 553; my translation from a citation of the original in Beer, p. 120.

12. Quesnay, "Corn," originally published as an article in Diderot's Encyclopedia; excerpted in Ronald Meek, The Economics of Physiocracy: Essays and Translations (George Allen Unwin, Ltd. London: 1962), pp. 72-87, p. 73.

13. A possible third is direct use of solar energy. Passive solar gain, however, does not enter into economic trade as do the products of agriculture and mining; for every house that is retrofitted to take advantage of solar gain, the Gross National Product of the country goes down (because fuel, which is included in GNP, is replaced by solar radiation, which is not). Conversion of solar radiation to electricity may, in the future, provide an economy with another source of low-entropy income, but it does not do so yet: current solar equipment is heavily subsidized by fossil fuel to such an extent that it does not yet produce a net low-entropy gain. (Georgescu-Roegen, "Technology Assessment: The Case of Direct Use of Solar Energy," Atlantic Economic Journal, December 1978, pp. 15-17.) By this criterion, modern agriculture doesn't provide a low-entropy gain, either. See John S. Steinhart and Carol E. Steinhart, "Energy Use in the United States

13. Continued
Food System," Science 184: 307-316 (19 April 1974), who estimate that as of 1970 we derived roughly one calorie of usable food energy for every nine calories consumed in the agricultural sector.

14. Nicholas Georgescu-Roegen, "Technology Assessment: The Case of Direct Use of Solar Energy," Atlantic Economic Journal, December 1978, pp. 15-21, p. 17. See also the Afterword that Georgescu-Roegen wrote for Jeremy Rifkin's Entropy: A New World View (The Viking Press, New York: 1980), pp. 261-269, p. 266: "We must refrain from speaking of the entropy of matter as a measurable entity. There is a measurable entropy for energy because energy is homogenous; matter in bulk is instead heterogenous....The factors that dissipate matter, therefore, vary greatly from one material substance to another; hence, we cannot (at this time) subsume all material dissipations into one general formula -- which does not mean that such dissipations do not take place irrevocably or that we cannot speak of the general degradation of available matter-energy into the unavailable form."

15. Kenneth Boulding, "The Economics of the Coming Spaceship Earth," in H. Jarrett, ed., Environmental Quality in a Growing Economy (Johns Hopkins Press, Baltimore: 1966), p.

16. Georgescu-Roegen does refer somewhat cryptically to "a few unorthodox economists" who have "shifted to a physiocratic position, albeit in greatly modified forms," and then lets us know, in his footnote to this sentence, that he counts himself among their number. See the title essay in his collection of articles, Energy and Economic Myths (Pergamon Press, New York: 1976; hereinafter, E&EM), p. 20.

17. Soddy, however, was a bit less terse in making his debts to physiocrats known. See his The Role of Money: What it should be contrasted with what it has become (Harcourt Brace and Company, New York: 1935), pp. 10-11.

18. The two articles by Daly are "The economic thought of Frederick Soddy," in History of Political Economy 12:4, pp. 469-488; and "Growth Economics and the Fallacy of Misplaced Concreteness," American Behavioral Scientist 24:1 (September/October 1980) pp. 79-106. Only the first of these is cited below, by author's name. The direct quotation comes from Daly, p. 471.

19. Frederick Soddy, Wealth, Virtual Wealth, and Debt (London: 1926), p. 28.

20. Daly, p. 471; Kuhn, The Structure of Scientific Revolutions, p. 89: "Almost always the men [sic] who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change."

21. Daly, p. 471; the second direct quotation in this sentence is from Soddy's obituary in Science, written by Alexander Russell, "F. Soddy, Interpreter of Atomic Structure," (30 November 1956, pp. 1069-70), cited by Daly, p. 471.

Soddy was not completely without influence, however. Although he failed to gain an ear among the economists of his day, his writing did influence a man named Howard Scott, who founded the "Technocracy" movement in this country during the Depression. Scott thought so highly of Soddy's work that he plagiarized some of it. The charge was brought by John Macrae, then president of E.P. Dutton and Co., and was based on a comparison of an article Scott wrote for Harper's to Soddy's Wealth, Virtual Wealth, and Debt. Scott also borrowed liberally from Thorstein Veblen's The Engineers and the Price System in advancing his notion that the engines of modern industrial production, if run for maximum efficiency by the emerging class of technicians (rather than by greedy capitalists or incompetent politicians), could produce enough material wealth to guarantee every adult American an income of $20,000 a year -- and that, with a work week reduced to sixteen hours. The movement grew and flourished briefly during the depression, suffered a bit of an eclipse during the modest upswing in the economy just before America's entry into World War II, suffered some embarassment consequent upon Scott's having praised Mussolini as a man of Technocratic principles, enjoyed a reprise of popularity during the war years (when Scott offered a great deal of shrill, unsolicited advice, none of which was heeded, to the Roosevelt administration, and then claimed America's economic successes as validation of his principles. For that claim he did have some justification). The declining movement collapsed in scandal when Scott was indicted for embezzling funds from the organization.

From Soddy Scott had taken the idea that energy is the source of all wealth -- simplifying the message somewhat as he broadcast it. The other components of his fascistic doctrine -- the belief that the American Bill of Rights and the notions of freedom, justice, and liberty that that document emobodies were "empty baubles of the social epoch of yesterday," his belief that "democratic methods are obsolete" -- come from different sources and have no foundation in Soddy's work. The quotations from Scott come from Paul Sann, Fads, Follies, and Delusions of the American People (Crown Publishers, Inc., New York: 1967) p. 82; see also William E. Akin's critical history of the movement, Technocracy and the American Dream (University of California Press, Berkeley: 1977). For a sample of Technocratic thinking, see Frank Arkwright, The ABC of Technocracy (Harper and Brothers, Publishers, New York: 1933), esp. chapter two, "The Story of Energy;" for hagiography of Scott, see various issues of The Technocrat, especially the issue for November 1942 in which Scott is proclaimed "America's Man of the Hour" in the cover story; for a more balanced view, see "The Enemy of the Bourgeoisie" in The New Yorker, 23: 18-19 (June 14, 1947).

22. Daly, paraphrasing Soddy, p. 479.

23. Daly, p. 477.

24. Soddy, Wealth, Virtual Wealth, and Debt, p. 70.

25. Daly, p. 475. This suggests that one impetus behind the economic evils that Soddy diagnosed is the breakdown of such "organic" forms of social security as the family and the church. The modern, state-operated social security system is impaled on just the sort of problem that Soddy foresaw.

26. Daly, p. 476.

27. Daly, p. 476.

28. Soddy, Inversion of Science (London: 1924), p. iv. The point is not, of course, that minor, as one can see by imagining trying to change it.

29. Aristotle, Politics (Modern Library, New York: 1942), trans. by Benjamin Jowett, pp. 71-2.

30. St. Thomas Aquinas, Summa Theologica, excerpted in A. E. Monroe, Early Economic Thought (Harvard University Press, Cambridge: 1924), p. 66.

31. Sir William Petty, Economic Writings (Cambridge: 1899), Vol. I p. 47.

32. Robert Heilbroner, An Inquiry into the Human Prospect (W.W. Norton and Company, Inc., New York: 1975), p. 169.

33. "More praised than read:" Nicholas Wade, "Entropy the Measure of Economic Man," Science 190:447-450 (October 31, 1975), p. 447; honored: The American Economic Review (June 1972, title page) honored Georgescu-Roegen as its Distinguished Fellow in 1971, paying "homage" to him as "a true Renaissance man;" "our generation's classic:" Library Journal, quoted on the jacket cover; Samuelson: quoted in Wade, p. 447. Wade also quotes Georgescu-Roegen as saying "future generations will speak my language," and as casting himself in the role, vis-a-vis other economists, of "the boy who stole all the marbles."

34. Nicholas Georgescu-Roegen, The Entropy Law and the Economic Process (Harvard University Press, Boston: 1971; hereinafter, Entropy Law) p. 2.

35. The biological analogy here should not be misinterpreted as suggesting that neophysiocracy involves recasting economic thought on an organic, instead of a mechanistic, base. The

35. Continued
neophysiocrats do see themselves as challenging the "mechanistic models" of orthodox economics (Georgescu-Roegen, Entropy Law, p. 19) and Georgescu-Roegen goes so far as to point out that among economists of distinction, "only Alfred Marshall [correctly] intuited that biology, not mechanics, is the true Mecca of the economist" (Entropy Law, p. 19). But the biology that is the Mecca of the economist is a biology enlightened by thermodynamics, one that appreciates that "any life bearing structure maintains itself in a quasi-steady state by sucking low entropy from the environment and transforming it into higher entropy" (Ibid., p. 10, paraphrasing Erwin Schrodinger). For an account of how the thermodynamic revolution hit biology in the 1930s and 40s, see Donald Worster, Nature's Economy (Anchor Press/Doubleday, Garden City, New York: 1979), chapter 14.

36. Georgescu-Roegen, E&EM, p. 10.

37. Georgescu-Roegen, Entropy Law, p. 18.

38. Ibid., p. 284, emphasis in original. Compare: "An unorthodox economist -- such as myself -- would say that what goes into the economic process represents valuable natural resources and what is thrown out of it is valueless waste." Georgescu-Roegen, "The Entropy Law and the Economic Problem," pp. 53-60 in E&EM, p. 53.

39. Georgescu-Roegen discusses the myth of infinite subsitution of factor inputs in "Energy and Economic Myths," p. 17 in E&EM.

40. Georgescu-Roegen, E&EM, p. xvii.

41. Agriculture and mining do not circumvent the second law, of course, and so we may be sure that they, too, contribute to a net increase in entropy. For agriculture, the "entropy account" is balanced in the sun, which is slowly burning up; solar income represents a net low-entropy gain for the planet, but in the relevant closed system (sun, planets, and space) entropy increases. For mining and extractive industries, the net entropy gain happened long ago: for coal and oil, the entropy account was again balanced in the sun, and for most ores the increase in entropy was manifest in the cooling of the earth's crust.

42. Georgescu-Roegen, E&EM, p. xvii. For an example of this sort of energy accounting, see R.A. Herendeen, T. Kary, J. Rebitzer, "Energy Analysis of the Solar Power Satellite," Science 205: 451-454 (3 August 1979). See also the articles collected in Energy Analysis, John A. G. Thomas, ed. (Westview Press, Inc., Boulder, Colorado: 1977).

43. Georgescu-Roegen cautions that low entropy is a necessary but not sufficient condition for a thing to have economic value. Poisonous mushrooms, for instance, have low entropy but no economic value. The relationship between low entropy and value is similar to that between value and price: just as an article will not have a price unless it has value, but not all valuable goods have prices (e.g. air), an article will not have value without low entropy, but the converse is not true. (See Entropy Law, p. 282.) But elsewhere Georgescu-Roegen suggests that "a problem of cost...in the perspective of this paper means a problem of a balance sheet in entropy terms" ("The Entropy Law and the Economic Problem," E&EM, p. 57). If we accept the notion that optimal allocation of resources is achieved within a market only when price reflects cost, then there is an implicit justification here for the implementation of policies that would cause ratios between prices to reflect relative entropy cost.

44. Except, perhaps, in the case of equipment designed to garner low entropy from sources other than accumulated stocks. This equipment would represent a capital investment in future low-entropy income, and so should be subsidized.

45. On Marx, see the collection of his writings about Malthus ed. by Ronald L. Meek, Marx and Engels on the Population Bomb (Ramparts Press, Berkeley, California: 1971). One of the main contributions of neophysiocracy is the exposure of the common root of Marxist and Western bourgeois economics: an implicit belief in the possibility of "bootlegging entropy" (in Georgescu-Roegen's colorful phrase), i.e. of overcoming the second law of thermodynamics in our productive activities. This implicit belief lies behind any theory that accepts the possibility of perpetual economic growth, or even (see below) the possibility of a perpetual "steady state" economy at a high level of development.

46. "The struggle for life which we observe over the entire biological realm is a natural consequence of the Entropy Law" and "broadly interpreted the economic process is a continuation of the biological one." (Georgescu-Roegen, Entropy Law, p. 307. I have so far left unremarked Georgescu-Roegen's habit of capitalizing "Entropy Law" throughout this work -- a measure of respect he does not grant the first law of thermodynamics.) In that process, humans use exosomatic instruments -- capital equipment -- which enable us "to obtain the same amount of low entropy with less expenditure of [our] ...own free energy" than if we relied, like other animals, on our endosomatic organs alone.

47. Georgescu-Roegen speaks of "recipes" for production, which consist of "known procedures for manipulating the material environment for some material purpose" and which have "specific flow and fund coordinates." That is, we have available to us different ways of accomplishing our ends, and these different ways use different mixtures of the low-entropy factor inputs. Georgescu-Roegen then offers a distinction between viable and feasible recipes: feasible means simply "do-able" (e.g., it is now "feasible" to mine the surface of the moon) while viable means that the technology is capable of supporting itself in low-entropy terms. Viable does not quite mean sustainable: steam technology, Georgescu-Roegen says, is viable (though we know that it isn't sustainable, given its reliance on limited stocks of fossil fuel) because the invention of the steam engine made vast quantities of coal accessible, which provided the energy to refine the ore to make more steam engines. This distinction is made in order to point out that "direct use of solar energy" (by which Georgescu-Roegen means only direct conversion of solar energy into electricity) is a feasible, but not yet a viable, technology. See "Technology Assessment: The Case of Direct Use of Solar Energy," *loc. cit.*

48. Georgescu-Roegen, *Entropy Law*, p. 303. Georgescu-Roegen's experience as a Rumanian who received an orthodox training in economics in Western schools, then returned to his native country, seems to have played a role in his having escaped from the standard economic paradigm. See his brief intellectual autiobiography in the foreword to *E&EM*, pp. xi-xiv.

49. There is even a more insidious flaw in an agricultural system that relies so heavily on subsidies from the scarce endowment of terrestrial low entropy. Mechanized, fossil-fuel intensive agriculture may lead to the extinction of species that played key roles in earlier, non-mechanized agriculture, and their loss may prevent our return to an organic, thermodynamically sane agriculture.

50. Georgescu-Roegen, *Entropy Law*, p. 304. Georgescu-Roegen admits that this fuzzes over some details. If S represents the terrestrial stocks of low entropy, and r the rate at which they are depleted, then $S = r \times t$, where t stands for some finite amount of time over which the stocks can be depleted. "The elementary formula shows that the quicker we decumulate S the shorter is t." But Georgescu-Roegen identifies t with the duration of the human species, which is not quite correct: it is the duration of exploitation of terrestrial stocks of low entropy, which means that it is the duration of the human species only if the human species must necessarily exploit stocks, as well as flows, of low entropy. Tractors may not eat people, if people can live without decumulating material low entropy from the environment.

51. Georgescu-Roegen tells us that one of the major questions facing the human race -- a question we shall answer either explicitly or implicitly -- is whether we, as a species, will have "an uneventful but long life" or a "short but thoroughly exciting and extravagant life." ("Bio-Economic aspects of Entropy," in Libor Kubat and Jiri Zeman, eds., Entropy and Information in Science and Philosophy [Elsevier Scientific Publishing Co., New York: 1975], pp. 125-142, pp. 141-142.) Elsewhere, he gives an indication that he sees how the question will be answered: "we must not doubt that, man's [sic?] nature being what it is, the destiny of the human species is to choose a truly great but brief, not a long and dull, career." Entropy Law, p. 304. See also his article "Technology Assessment..." for a pessimistic view of the prospects of solar energy. His argument there is flawed by mistaking direct conversion of sunlight to electricity as the only possible "direct use" of solar energy, and by an appeal to negative evidence: "the absence of experimental pilot plants proves" that photovoltaics is not a viable technology. (p. 19.) For a more technical treatment of the same subject, one that arrives at a similarly pessimistic conclusion that a solar society much beyond the level of rudimentary agriculture is probably not sustainable, see Howard Odum, "Net Energy from the Sun," pp. 196-211 in Sun!: A Handbook for the Solar Decade, ed. by Stephen Lyons (Friends of the Earth, San Francisco: 1978).

52. "Energy and Economic Myths," in E&EM pp. 33-4.

53. This is a path that Georgescu-Roegen flirts with, especially when he calls for "coordination of all national [economic development] plans...through some international agency" in order to avoid wasteful duplication of industrial plant capacity. (Entropy Law, p. 294.) Generally, though, Georgescu-Roegen manages to steer clear of specifically political issues in his exposition of the relevance of thermodynamics to economics. He notes that social conflict has an origin in distribution of the products of an economy, and hence in the human thermodynamic condition, and seems to agree with Marx that public authority exists to regulate that conflict (while disagreeing with the basic Marxist tenet that fundamental scarcity can be overcome). (Entropy Law, pp. 306-315, Chapter X section 4 titled "From the Struggle for Entropy to Social Conflict".) He is ill at ease with any movement for reform guided by a vision of a "rational" society, for he realizes that any definition of rational behavior is likely to be either culture-bound or tautological. (Entropy Law, pp. 345-359.) But nowhere does he specifically address what sort of political arrangement might be most conducive to the creation of an economic system that is thermodynamically sane, nor does he linger on the sorts of specific policies that could begin to implement the vision he has articulated.

54. See Amory Lovins, Soft Energy Paths: Toward a Durable Peace (Ballinger Publishing, Cambridge, Mass.: 1977) for a rigorous development of what a relatively decentralized, renewable energy infrastructure would look like.

55. Arne Naess, "The Shallow and the Long-Range, Deep Ecology Movement. A Summary," Inquiry 16: 95-100.

56. An account of this influence can be found in The Correspondence of Jefferson and DuPont de Nemours (Johns Hopkins Press, Baltimore: 1931), edited and with an introduction by Gilbert Chinard.

57. Lovins prefaces his work (sse note 53, above) with a declaration of his political beliefs, in which he explicitly invokes the name of Jefferson, p. 14. He makes no mention of physiocrats, however.

58. See Georgescu-Roegen's delicately worded criticism of those who do try to apply the idea of entropy to such affairs in his afterword to Rifkin's book, p. 263.

59. "Energy and Economic Myths," in E&EM p. 30.

60. The phrase quoted comes from Eugene Bardach, "Energy Conservation Considered as a Political Ideology," a paper delivered at a meeting of the Western Political Science Association in San Francisco, 2 April 1976, p. 11. Wilhelm Ostwald was perhpas the first to derive a moral theory from the laws of thermodynamics, and his view is echoed more recently by Kenneth Boulding, who suggests that "it is at least a useful first approximation of the problem of moral value to suppose that the highest test of a value is whether it performs an entropic or an anti-entropic function in society." (The Meaning of the Twentieth Century, Harper and Row, New York: 1964, p. 146.) The most succinct statement of the moral imperative suggested by thermodynamics remains, however, Ostwald's: "do not waste energy!" This is a trifle too succinct to be illuminative, or fully representative of the moral theory suggested by neophysiocracy; it is difficult to see, for instance, how an injunction against usury could be developed directly from that bit of advice.

61. E.F. Schumacher, Small is Beautiful (Harper and Row, New York: 1973), p. 53.

62. J.S. Mill, Autobiography (Henry Holt and Company, New York: n.d.), especially chapter 5, "A Crisis in My Mental History," pp. 132-141.

63. Among the passages in Georgescu-Roegen's work that supports the charge that he is guilty of perpetuating the standard dichotomy between humans-as-producers and humans-as-consumers is one in Entropy Law, pp. 284-5: "daily life enjoyment is enhanced by an increase in the flow of consumer goods one can consume daily as well as by a longer leisure time. On the other hand, the enjoyment of life is diminished if one has to work longer hours or at a more demanding task."

Notes to Chapter Seven

1. Henrik Hertzberg and David McClelland, "Paranoia," _Harper's_, 248: June 1974, pp. 51-4, p. 54.

2. William Feller, _An Introduction to Probability Theory and Its Applications_, I (John Wiley, New York: 1957) p. 152.

3. Thomas Pynchon, "Entropy," pp. 81-98 in _Slow Learner: Early Stories_ (Little, Brown and Company, Boston: 1984), p. 84.

4. _Ibid._, p. 89.

5. Thomas Pynchon, "Introduction," _Slow Learner_, pp. 12-14; he sees it as "too conceptual, too cute and remote"; remarks that "people think I know more about the subject of entropy than I really do," and that "Since I wrote this story I have kept trying to understand entropy, but my grasp becomes less and less sure the more I read"; calls his understanding shallow and allows as how he was "more concerned with committing on paper a variety of abuses, such as overwriting," than in presenting entropy thoroughly.

6. William Vesterman, "Pynchon's Poetry," pp. 101-112 in George Levine and David Leverenz, eds., _Mindful Pleasures: Essays on Thomas Pynchon_ (Little, Brown and Company, Boston: 1976). This collection will hereinafter be cited as Levine and Leverenz. Vesterman points out that Pynchon's books average a line of verse or song for every page.

7. Edward Mendelson, "Gravity's Encyclopedia," pp. 161-195 in Levine and Leverenz, touches on all of these; more specifically, see Lance W. Ozier, "Antipointsman/Antimexico: Some Mathematical Imagery in _Gravity's Rainbow_," _Critique_ 16, No. 2 (1974), pp. 73-90; Ozier, "The Calculus of Transformation: More Mathematical Imagery in _Gravity's Rainbow_," _Twentieth Century Literature_ 21, No. 2 (May 1975), pp. 193-210; Anne Mangel, "Maxwell's Demon, Entropy, Information: _The Crying of Lot 49_" pp. 87-100 in Levine and Leverenz; Alan J. Friedman and Manfred Puetz, "Science and Metaphor: Thomas Pynchon and _Gravity's Rainbow_", _Contemporary Literature_ 15 (Summer 1974), pp. 345-359; Peter L. Abernathy, "Entropy in Pynchon's _The Crying of Lot 49_," _Critique_ 14, No. 2 (1972), pp. 18-33; and Thomas R. Lyons and Allan D. Franklin, "Thomas Pynchon's 'Classic' Presentation of the Second Law of Thermodynamics," _Bulletin of the Rocky Mountain Modern Language Association_ 27 (1972), pp. 195-204.

8. Marjorie Kaufman, "Brunhilde and the Chemists: Women in Gravity's Rainbow," pp. 197-227 in Levine and Leverenz; Catherine R. Stimpson, "Pre-Apocalyptic Atavism: Thomas Pynchon's Early Fiction," pp. 31-47 in Levine and Leverenz; "Nosepicking Contests," Time 87 (May 6, 1966), pp. 109-10.

9. See the works cited in note seven, above.

10. Weber: See Mendelson, "Gravity's Encyclopedia" and Thomas H. Schaub, Pynchon: the Voice of Ambiguity (University of Illinois Press, Urbana: 1981), chapter on "Max Weber and the 'disenchantment of the world'", pp. 57-66. Adams: see Joseph P. Sperry, "Henry Adams and Thomas Pynchon: The Entropic Movements of Self, Society, and Truth." Dissertation Abstracts International 35 (February 1975), 5428A (Ohio State University). Marshall McLuhan: Joseph Slade, "Escaping Rationalization: Options for the Self in Gravity's Rainbow", Critique, 18, No. 3 (1977), pp. 27-38. Mircea Eliade: Edward Mendelson, "The Sacred, the Profane, and The Crying of Lot 49," in Pynchon: A Collection of Critical Essays, ed. Edward Mendelson (Prentice Hall, Englewood Cliffs, New Jersey: 1978). Carl Jung and Ludwig Wittgenstein: See Schaub, pp. 49-57 and pp. 81-82, respectively.

11. Scott Sanders, "Pynchon's Paranoid History," in Levine and Leverenz, pp. 139-159; Ozier, op. cit.; Robert E. Golden, "Mass Man and Modernism: Violence in Pynchon's V.", Critique 14, No. 2 (1972), pp. 5-17; Tony Tanner, "Caries and Cabals," pp. 49-67 in Levine and Leverenz; Schaub, op. cit.

12. A bit of information offered by Levine and Leverenz in their "Introduction," pp. 3-4.

13. Schaub, for instance; see p. 152. See also the embarassing anthem with which Annette Kolodny and Daniel James Peters end their article, "Pynchon's The Crying of Lot 49: the Novel as Subversive Experience," Modern Fiction Studies 19 (Spring 1973), pp. 79-87.

14. Levine and Leverenz, "Introduction," p. 4

15. Pynchon, Gravity's Rainbow (Bantam Books, New York: 1973). Some examples: "I Ching feet," pp. 870-1; a law firm with the Hobbesian title "Salitieri, Poore, Nash, De Brutus, and Short," p. 689; a story leading up to the exclamation "For de Mille, young fur-henchmen can't be rowing!", p. 651.

16. Levine and Leverenz, p. 4. See also Richard Poirier, "The Importance of Thomas Pynchon," in Levine and Leverenz, pp. 15-29, p. 19; and Edward Mendelson's "Introduction" to Pynchon: A Collection of Critical Essays.

17. "One suspects that he could churn out a passable almanac in a fortnight's time," wrote George Plimpton upon reading Pynchon's first novel. (Quoted in "Pynchon, Thomas," in Contemporary Writers [Gale Research Company, Detroit, first revised edition 1976], Clare D. Kinsman, ed., p. 594-5, p. 594.

18. Henry Adams, Education, p. 410 (See chapter five for full citation); see Schaub, p. 114: "Most authors who flood their books with facts drawn from the real world do so in an effort to create the illusion of realism and [to] gain credibility for their plots and characters....By contrast, the first effect of Pynchon's facts is the violation of plausibility."

19. Schaub, p. 17.

20. Mendelson, "Gravity's Encyclopedia," p. 188.

21. Levine and Leverenz, "Introduction", p. 9.

22. "Cavities in the teeth occur for good reason, Eigenvalue reflected. But even if there are several per tooth, there's no conscious organization there against the life of the pulp, no conspiracy. Yet we have men like Stencil, who must go about grouping the world's random caries into cabals." V. (Bantam Books, New York: 1964), p. 139. But then perhaps the "psychodontia" of Dudley Eigenvalue, D.D.S., who offers this judgment, is flawed in its inability to imagine that caries could be the result of some conspiracy between other dentists and sugar manufacturers that he is not privvy to?

23. Scott Sanders, "Pynchon's Paranoid History," loc. cit., p. 145.

24. Sir E. A. Budge, The Egyptian Book of the Dead (Barnes and Noble, New York: 1969), p. 25.

25. Schaub, p. 35, points out the connection to the forty-nine days of the soul's Bardo existence, but reads the ending of the book differently; he sees it as a moment of incipient revelation and therefore of incipient death. He does not see the possibility that the period of Oedipa's life taken up in the novel is a Bardo existence (started, fittingly, by the death of Pierce Inverarity, her ex-lover); the moment of revelation toward which the book builds (but which is of course denied to us; perhaps the actual crying of lot 49 will not resolve Oedipa's uncertainties) is more like a moment of rebirth.

26. Compare the passage in which Pynchon romanticizes epilepsy (p. 69), which helps to gloss this usage of the term: "She could, at this stage, recognize signals like that, as the epileptic is said to -- an odor, color, pure piercing grace note announcing the seizure. Afterward it is only this signal, really dross, this secular announcement, and never what is revealed during the attack, that he remembers."

27. "Oedipa believed...in some principle of the sea as redemption for Southern California...some unvoiced idea that no matter what you did to its edges the true Pacific stayed inviolate and integrated or assumed the ugliness at any edge into some more general truth." p. 37.

28. Although Pynchon's works contain a dizzying amount of factual information, the reader is drawn into adding to that other facts that help understand the text, and in so doing is forced into making connections that must then be juggled into meaning, "all the while wondering whose connections they are, his [sic] or Pynchon's." Schaub, p. 116.

29. A judgment offered by Schaub, whom I am here trusting. I don't think we can credit what Pynchon is reported to have said to an old college roomate concerning his absolute ignorance of the historical Thurn and Taxis; he told Jules Siegal (Siegal tells us) that he made the whole thing up and was amazed when he started getting "weird letters" telling him it was true. See Siegal, "Who is Thomas Pynchon...and why did he take off with my wife?", Playboy, March 1977, pp. 97 and following.

30. Thomas Pynchon, "Mortality and Mercy in Vienna," Epoch vol. 9 no. 4 (Spring 1959), pp. 195-213. In the story, the myth of the Windago seems more improbable than the crossed guns on the bedroom wall of the apartment in which a cocktail party is being hosted; when the host of the party whispers the single word "Windago" into the ear of an Ojibwa guest, and leaves, we understand what will happen next: a sacrament of sorts, initiated this time by the host, as the Ojibwa, possessed by the spirit, wreaks havoc on the party goers. For the malevolent connections between Shell Oil, I.G. Farben, and the Nazis mentioned in the next clause in the text, see Joseph Borkin, The Crime and Punishment of I.G. Farben (Free Press, New York: 1978).

31. Paraphrasing Schaub, p. 114 (see quotation in note 18).

32. My own humble contribution to de-coding Pynchon is to point out that one of the passages that resonates with Oedipa's Either/Or crisis, the tale of Confederate man-of-war Disgruntled (Lot 49, pp. 31-3), owes something to Aristotle's

32. Continued
passage on the sea battle: "I mean, e.g. that it is necessary that there will be a sea-battle tomorrow or not, but that it is not necessary that there should be a sea-battle tomorrow, nor that it should not happen." (From De Interpretatione, Chapter IX; see the version of Aristotle's text with a commentary by G. E. M. Anscombe to be found in J. J. C. Smart, Problems of Space and Time (MacMillan Publishing Co., New York: 1964) pp. 43-57, where the passage cited can be found on p. 49.

33. Schaub, p. 125.

34. Schaub, p. 125.

35. This fact is noticed by Roger Mexico, who has been mapping rocket strikes in London. They conform to a Poisson distribution -- a random distribution in geographic space -- but the circles with which he marks the rocket hits match exactly the location of the stars on a different map with which Slothrop, the American G.I., marks his sexual encounters. Mexico projects a slide of his map onto Slothrop's to discover this, producing neat mandala-like designs, stars inscribed in circles, procreation in death -- another tension the novel embodies. Many residents of London believed that rocket strikes during the war were not random, but had a tendency to cluster. The pattern of rocket strikes is used in several textbooks as an illustration of the Poisson distribution, and Feller -- from whom one of the epigraphs to this chapter is drawn -- specifically mentions the folk belief in pattern in his use of the example. Pynchon may have read this text, but probably got his information from another source; see Schaub, pp. 108-9, p. 137.

36. "You will want cause and effect," the narrator of Gravity's Rainbow (Bantam Books, New York: 1973) wearily surmises at one point (p. 727). "All right" -- and then proceeds to offer a portion of the narrative that suggests a causal relationship within two events only after thirty pages or so. Schaub finds that this passage is not proof of Pynchon's rejection of cause and effect, as some take to be, but evidence of a disdain for causality that derives from the fact that "as author he is able to transcend the more narrow cause-and-effect world and write in the fourth dimension of time unavailable" to his characters, p. 8. Compare Gravity's Rainbow (hereinafter, simply GR), p. 195, where Walter Rathenau, a (perhaps malevolent and therefore perhaps obsfuscatory) spirit speaking from the Other Side, warns: "All talk of cause and effect is secular history, and secular history is a diversionary tactic."

37. "Entropy," loc. cit., p. 91. This exchange takes place just after Saul has explained to Meatball that he and his wife had a fight about information theory -- "a field you could go off the deep end in," he explains.

38. Thomas Pynchon, "A Journey Into the Mind of Watts," pp. 146-158 in Man Against Poverty: World War III, ed. by Arthur I. Blaustein and Roger R. Woock (Random House, New York: 1968); originally published in New York Times Magazine, June 12, 1966.

39. "Introduction" to Slow Learner, pp. 4-5.

40. Lot 49, p. 106.

41. "[The values the novel Gravity's Rainbow presents] exist not in single elements...but among the fragments and between the characters....[and among those characters we find] no one to hate...The characters...are given too much human detail, we know too much about their fears, ambitions, dreams...." Schaub, pp. 135-7.

42. Kolodny and Peters, p. 86.

43. Oedipa, in Lot 49, has a conversation with an anarchist who tells her "You know what a miracle is. Not what Bakunin said. But another world's intrusion into this one. Most of the time we coexist peacefully, but when we do touch there's cataclysm. Like the curch we hate, anarchists believe in another world. Where revolutions break out spontaneous and leaderless, and the soul's talent for consensus allows the masses to work together without effort, automatic as the body itself." (pp. 89-9). This evokes Pynchon's thoughts on revolutionary violence in "A Journey Into the Mind of Watts," and is specifically recalled by Oedipa in her experience at the deaf-mute convention.

44. Thus, despite the Sophoclean timbre of her name, Oedipa is not a metaphor or a symbol for something, but very much a metaphor incarnate; see my discussion of the relationship between metaphors and communities, p. 38.

45. Richard Poirier, op. cit., p. 6.

46. Mendelson, "Gravity's Encyclopedia," p. 165.

47. The mid- to late seventies saw a burgeoning literature celebrating the advent of "transnational relations," i.e. relations between state and non-state actors in the international system that tended to abrogate state sovreignty; see Robert O. Keohane and Joseph S. Nye, Power and Interdependence: World Politics in Transition (Little, Brown and Co., Boston: 1977) for an example of the genre.

48. Sanders, _op._ and _loc._ _cit._

49. Richard Hofstadter, "The Paranoid Style in American Politics", in _The Paranoid Style in American Politics and Other Essays_ (Vintage Books/Random House, New York: 1967), pp. 3-40, p. 36.

50. Hofstadter, pp. 6, 3, 29, 31, 31, and 32, respectively.

51. Sanders, pp. 157-9, offers four "political and philosophic" objections to the view of history and humanity he finds in Pynchon's _Rainbow_: Pynchon's fictions tend to further mystify, rather than de-mystify, social relations; the paranoid style of understanding is solipsistic, which is just what a totalitarian power would desire in its populace; Pynchon "reifies technology" into "a metaphysical principle standing outside human control"; and Pynchon has presented a peculiarly modern social condition -- "the anomic, manipulated, paranoid individual within advanced industrial society" -- as if it were the human condition. The second criticism mistakes Pynchon's social criticism for his positive agenda (always a danger when reading epic literature); the first is a matter of judgment (the partisan might say that Pynchon has captured those relations in all their complexity, providing his readers with a useful map of the territory), the third is correct but hardly a telling criticism, given that the mythology of human control of technological forces is itself a widely-shared but nonetheless 'delusional' belief system; and to the fourth we may simply answer, "So what? It _is_ -- _now_."

52. _GR_, pp. 276, 280-1, 293, 304, 340.

53. Again, my elipsis in brackets, the rest, Pynchon's. One could write an entire article exploring the implications of the word "religious" in this quotation, connecting it to Slothrop's (and Pynchon's own) Puritan ancestors. And indeed, it is a theme that Sanders explores: "God is the original conspiracy theory....A mind that preserves Puritan expectations [for the discovery of order, meaning, and purpose in the world] after the Puritan God has been discredited will naturally seek another hypothesis....paranoia is the last retreat of the Puritan imagination." pp. 139-40.

54. Schaub, again; p. 136.

55. See the passage on the New Turkish Alphabet, _GR_, pp. 410-414. Tchitcherine -- a Russian character in the novel -- is dispatched by his superiors to join the committee devising an alphabet for the Kirghiz people, who have an oral culture, "not even an Arabic script to replace." The new alphabet

55. Continued
becomes the focus of political wrangling, as cultural subgroups represented on the committee want their traditions represented in the alphabet; it all comes to a head over which "g" to use in the word "stenography". The tale is comic, and at least one of Pynchon's jokes gets to the heart of the matter: after the institution of the new written language, bureacracies among the Kirghiz are made possible, and with them something else: "On sidewalks and walls the very first printed slogans start to show up, the first Central Asain[...]kill-the-police-commissioner signs (and somebody does! this alphabet is really something!)...." The passage continues, and makes explicit the political force of language: "so the magic that the shamans, out in the wind, have always known, begins to operate now in a political way." In Pynchon's work language occasionally succeeds in connecting people, in binding them together: Tchitcherine's father, on shore leave, met a Herero girl, and by "the time he left, they had learned each other's names and a few words in the respective languages -- afraid, happy, sleep, love...the beginnings of a new tongue, a pidgin which they were perhaps the only two speakers of in the world". (409) But language is ultimately limited: the NTA episode demonstrates, Mendelson tells us, that Gravity's Rainbow "itself must use a language that is, unavoidably, a system shaped by the very powers and orders it hopes to reveal. Language can never be liberated from lies." (op. cit., p. 169) Pynchon offers a few markers toward possible transcendence of the paradoxes of language: the village aqyn's poetic song (which Tchitcherine takes down, in stenography) about the Kirghiz light suggests meanings beyond language:

If words were known, and spoken,
Then the God might be a gold ikon,
Or a page in a paper book.
But It comes as the Kirghiz Light--
There is no other way to know it.

Schaub disagrees with Mendelson's estimation of what Pynchon is saying about language in the NTA passage: "Pynchon's Kirghiz episode dramatizes language as a force in the world and not as a limit of our being. By insisting upon the power of language in the world, Pynchon's writing helps preserve a critical distance between private thought and public vision. His writing keeps us in an uncertain but engaged equilibrium between the extremes of self and society." p. 152. The factual roots of the Kirghiz/NTA episode can be discovered, as Mendelson points out, in Thomas G.

55. Continued
Winner, "Problems of Alphabetic Reform among the Turkic Peoples of Soviet Central Asia, 1920-41," _Slavonic and East European Review_, 31, no. 76 (December, 1952), pp. 133-47.

56. See Matthew Winston, "The Quest for Pynchon", in Levine and Leverenz.

57. Schaub, pp. 18-9.

58. See Bateson, "Style, Grace, and Information in Primitive Art", pp. 128-152 in _Steps to an Ecology of Mind_ (Ballantine Books, New York: 1972), p. 142: "Some types of knowledge can conveniently be sunk to unconscious levels, but other types must be kept on the surface....The lion can sink into his unconscious the proposition that zebras are his natural prey, but in dealing with any particular zebra he must be able to modify the movements of his attack to fit with the particular terrain and the particular evasive action of the particular zebra." The connections that can be drawn between this essay of Bateson's, first published in 1967, and _Gravity's Rainbow_ have not, to my knowledge, been explored by anyone. Bateson comes to describe mental processes in terms of _circuits_, which are cut by the line that separates primary from secondary processes: all that is accessible to the secondary or conscious mind are "short arcs" of the complex webs of connections of the mind. Gravity's Rainbow is, of course, an arc. The similarity between Pynchon's Other Side and Bateson's primary processes has been noted in the text; more tellingly, both Bateson and Pynchon are concerned to have us establish connection between primary processes and secondary processes, this side and the Other Side: Bateson by developing a noetic appreciation of art, Pynchon by offering us a work of art that suggests the processes by which art comes into being. Bateson goes on in the article cited to hold that the short arcs of circuits that noetic consciousness can apprehend all have to do with the objects of attention of human purposive activity, and that "mere purposive rationality unaided by such phenomena as art, religion, dream, and the like, is necessarily pathogenic" precisely because the deeper network of connections is inaccessible to it, and yet it mistakes the part for the whole (p. 146). Religion and dreaming as ways of knowing both figure prominently in _Gravity's Rainbow_, and to Pynchon partial consciousness is paranoid consciousness.

Notes to Chapter Eight

1. Stephen Pepper, World Hypotheses (University of California Press, Berkeley: 1948) p. 340.

2. Donald Worster, Nature's Economy: the Roots of Ecology (Anchor/Doubleday, Garden City, New York: 1979) p. 292.

3. Worster, p. 296, quoting Charles Elton.

4. Worster, pp. 291-315 (chapter titled "Producers and Consumers") passim. A. G. Tansley, among thermodynamically-oriented biologists of this period, abjured all talk of community. He seems to have wanted to use thermodynamics to establish biology as a mechanistic science. See Worster, p. 319.

5. The "Acadian sense of fellowship with nature" is one of the themes of Worster's book, and he notes its absence in the "New Ecology," p. 314.

6. Arne Naess, "The Shallow and the Deep, Long-Range Ecology Movement. A Summary," Inquiry 16, 95-100, p. 95.

7. Thomas Kuhn, The Structure of Scientific Revolutions (University of Chicago Press, 1970).

8. It is, unfortunately, not uncommon for contemporary scholars to arrive at the conlusion, through a misreading of metaphor and other literary devices, that a classic work actually satirizes the ideas it contains. Thus, Arlene Saxonhouse's reading of Plato's Republic; she finds her clues to a satiric meaning in the work's animal imagery. See Saxonhouse, "Comedy in Callipolis: Animal Imagery in the Republic", American Political Science Review 72: 888-901.

9. A similar point is made by Oedipa's anarchist acquaintance in The Crying of Lot 49: continuing after the passage on "anarchistic miracles" cited in note 43 to chapter 7, Jesus Arrabal, the anarchist, says "And yet...if any of it should ever really happen all that perfectly, I would also have to cry miracle. An anarchist miracle. Like your friend [Inverarity]. He is too exactly and without flaw the thing we fight. In Mexico the privilegiado is always, to a finite percentage, redeemed -- one of the people. Unmiraculous. But your friend, unless he's joking, is as terrifying to me as a Virgin appearing to an Indian." p. 89, my emphasis and elipsis.

10. Brooks Adams, in the Preface to the Law, p. 59.

11. This is what the world theory of organism does, according to Pepper: in its efforts to maintain the fundamental vision of connectedness and integration, it is constantly "tempted to throw 'facts' out into the unreal." World Hypotheses, p. 145.

12. Pepper, World Hypotheses, p. 93.

13. Wilhelm Ostwald, "The Philosophic Meaning of Energy," International Quarterly, vol. 7 (1903), pp. 300-315, p. 312.

14. Henry Adams, "The Tendency of History," loc. cit., p. 126.

15. Anatol Rapoport, "Various Meanings of 'Theory'", American Political Science Review, 52 (1958): 972-988.

16. The epigraph, fittingly enough, presents one of the axioms of information theory (if we but substitute "information" for "theory"), derived from the probabilistic nature of the law of entropy.

17. Pepper, World Hypotheses, p. 101.

18. Pepper, World Hypotheses, p. 104; see also p. 98.

19. Pepper, World Hypotheses, p. 104.

20. "My aim is...to present the root metaphor and the set of categories of each of the four theories in its purest form," Pepper, World Hypotheses, p. 149; quotation in text, p. 149.

21. Pepper, World Hypotheses, p. 113.

22. Michael Walzer, "On the Role of Symbolism in Political Thought," Political Science Quarterly, vol. 82 no. 2 (June 1967), pp. 191-205.

23. Hugh Drummond, "Diagnosing Marriage," Mother Jones, July 1979, p. 16.

24. Wolfgang Giegerich, "Saving the Nuclear Bomb," paper presented to the Facing Apocalypse Conference in Newport, Rhode Island; summarized and excerpted in The Tarrytown Letter, Sept. 1983, p. 9.

25. Susan Sontag makes this point about metaphor in Illness as Metaphor (Vintage Books, New York: 1977) pp. 24-5.

26. Nicholas Georgescu-Roegen, "Afterword" to Jeremy Rifkin's Entropy· A New World View (Viking Press, New York: 1980), p. 266.

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