THE COSMIC BREATH: REFLECTIONS ON THE THERMODYNAMICS OF CREATION

by Jeffrey S. Wicken

Abstract. This paper views such distinctions as creation and degeneration or good and evil in the Eastern sense of unity in polarity rather than in the Western sense of dual, antagonistic principles. Hence it considers the thermodynamic forces of evolution as processes of creation driven by entropy dissipation and explores the analogies this conception bears to the Hindu image of nature as the changing mist of a universal breath. Using this image, the paper examines the sense in which the second law of thermodynamics connects chance and teleology in the operations of nature and provides for a causal hierarchy in which decision and volitional behavior co-participate with the laws of nature to determine the course of evolution.

William James once defined metaphysics as nothing but an unusually obstinate effort to think clearly. This was certainly a useful working perspective for one struggling to elevate a complex new discipline (psychology) into scientific respectability; but this perspective, in the hands of those who lack James's deep appreciation of the irreducibility of experience to formal abstractions, can lead down some very reductionist roads. Of the searchers for clarity, the Eleatics Parmenides and Zeno come first to mind, each in his own way sacrificing the phenomenal world of change and time to a static one of logical necessity. But while logic and mathematics may be true within their axiomatic frameworks, the history of science and philosophy makes it clear that their application to nature is problematic. The Eleatic lesson remains that rigor is often exacted at a cost of nature's implicit content. It is therefore important to attach to James's definition the rider that metaphysics involves the equally obstinate search for *completeness*, for concepts sufficient to apprehend the complexity of the world in which we find ourselves.

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The elaboration of such concepts never proceeds directly from the mind's analytical sense, but rather from its ability to move laterally, metaphorically, to map out the terrain of the unknown in categories and images of the familiar. The quest for completeness has its pre-metaphysical sources in myth—understood as that mode of expression which aims explicitly at depicting the fullness of the human condition, at locating humans in a physical, social and moral cosmos. As such, it must apprehend in some valuational way those basic polarities of experience that we come to know abstractly as order and disorder, good and evil, generation and corruption. Myth maps out this terrain in concrete terms, so that there is no distinction between a symbol or meaning and its exemplification (Macquarrie 1977, 134). This identity fractures and separates in the philosophical phase of human thought, the job of philosophy being in large measure the making of distinctions and the freeing of meanings from special contexts, a process which establishes an "objective" relationship between knower and known.

Objectification aims to unfold the implicit content of being into the explicitness of the concept. In spite of the epistemological problems and limitations connected with this enterprise, objectification does serve to liberate thought from the bondage of the given and its elaboration, for example in scientific theory, constitutes a definite kind of intellectual progress. But this "progress," discussed by August Comte as an ontogeny of human thought from the mythico-religious to the metaphysical to the positivistic, is anything but pure (see Mazlish 1972, 173-77). Philosophy and science carry with them, and draw upon, the subjective content of experience mapped out by myth, albeit in abstract categories. To the extent they engage nature and man in nature, philosophy and science can never be, and should never attempt to be, fully rational enterprises; they are obliged always to move within the fabric of meaning provided by the human agent in interaction with nature. On the one hand, this prescribes for the philosopher the ongoing job of trying to unmask nature, of sorting out and assessing the anthropomorphic content of theory and metaphysics (Turbayne 1970, 50). On the other hand, it expresses the ultimate bondage of thought to anthropomorphisms, to images that in some way grip the intelligence. The notion that one might illuminate human experience by drawing on models from science is therefore imperiled not only by reductivist excesses but also by the temptation to believe that such models provide a view, if ever so skeletal, of an exteriorized reality whose objectivity one can trust. With this disclaimer, we glance briefly at the "objectivity" of the moral domain made available by metaphor from science.

The strategy of metaphor is to use some well-understood phenomenon to illuminate one that is poorly understood; by this, the alien is

made familiar—in personal experience and in science—with metaphors becoming models and pursuing, if they are fruitful, lives of their own. Metaphorical thinking enjoys a qualified methodological sanction in science, because science deals with phenomena or concepts that are in an important way the same kind, having certain identities in space and time. Can this mode of reasoning have more than heuristic or poetic value when the concepts compared are not of the same kind? Good and evil, for example, have no spatio-temporal identities, so any objectivity they might be accorded lies in the possibility of abstracting from their occasions of experience some general, socially contexted meanings. That one might gain insight into the structure of the moral domain, which fundamentally involves freedom, by considering its formal analogies to the essentially unfree structure of the physical cosmos seems dubious. But in another sense the ethical domain is deeply intertwined with the physical, since the latter provides rules and boundary conditions for all behavior, including the volitional and the ethical. It is in this spirit that the following discussion will proceed.

When one speaks of dispositions in the physical cosmos these days, one generally means its tendency to produce entropy in certain kinds of irreversible processes. If entropy is interpreted as a kind of disorder or degeneration, physical processes would indeed seem to bear an interesting analogy to the less attractive of human inclinations. Whereas entropy has nothing whatever to do with moral turpitude, the two concepts nevertheless bilaterally interact, with the concept of entropy being influenced by prevalent notions of human disorder, then feeding back on the latter to give it pictorial clarity. The sense and semantic peril of this interaction, and its basis in the primary human experience of time, will be the subject of the first part of this paper. The remainder will attempt to present a more vitalized interpretation of the entropy principle, whereby the possibilities for self-activity it makes available can be understood as establishing the very conditions under which free, ethically significant behavior is possible at all. In this, much will be said of the amoral creative power of the entropy principle and of the religious implications that attend it.

The Experience of Entropy

No one really believes in the purity of Baconian objectivism anymore, in the idea that one can sift nature for self-standing facts in the same kind of eyes-open, imagination-suppressed way one might pan for gold. Still, the temptation remains to regard scientific laws, once formulated, as being somehow independent of their own histories, as value-free things that manage ultimately to rise above all the nonempirical, nonrational ingredients that went into their developments. Cer-

tainly, it is tempting to see the second law of thermodynamics in this light. Classical thermodynamics, in which the second law is nested, has been regarded by many as the very paradigm of enlightened nineteenth-century positivism, being derived with no theoretical presuppositions about the nature of matter or energy from the empirical asymmetry of heat-work interconversions. Given this asymmetry in nature's macrodynamics, entropy was defined in terms of two measurable parameters—heat and temperature—such that it had the property of increasing in spontaneous processes. (Briefly, and somewhat roughly, entropy is defined in differential form as the heat produced by a process dQ divided by the absolute temperature T at which it occurs, according to the equation $dS = dQ/T$. Thus, flows of heat from higher to lower temperatures are natural, entropy-producing phenomena ($Q/T_2 - Q/T_1 > 0$), whereas flows against temperature gradients are not, although both are perfectly commensurable with energy conservation. A corollary of this is that one can get a complete conversion of mechanical work or chemical potential energy to heat, but not vice versa.)

What could be cleaner than this, more value free? Even the statistical interpretation of the second law seems to provide its rationalist insights into the causal nature of this asymmetry at the expense of very little anthropomorphizing. If one regards the universe as corpuscularly constituted, as it appears in some ways to be, and as governed by a microdynamics that is blind with respect to the outcomes of process, then the second law seems to follow from the logical necessity of systems, given a random source of motion, to move toward states of maximum probability. Indeed, the second law seems so fundamental in this regard as to claim the status of a "metalaw," to which nature must a priori be bound (Wicken 1981, 129-43).

At the same time, popular interpretations of the entropy principle are anything but value-neutral, as evidenced by the descriptors (disordering, disorganizing) that are so often attached to its operation. In part, this usage reflects an infelicitous effort to give a formal concept some kind of pictorial clarity; but it also reflects a tendency for the existential blurringly to intrude on the conceptual. The presiding image of the cosmic heat-death has much to do with the thanatopsic meanings assigned the second law; but this image seems itself deeply grounded in Western culture, with its individualistic ego orientation on the one hand and its notion of time as the irreversible medium for the cosmic drama between God and man on the other.

In its existential expression, the entropy principle is very much of prescientific origins, deriving from a fundamental experience of ourselves as contingent beings ruled by time. Of the five kinds of experi-

ence distinguished by Philip Hefner with which the second law has been associated (running down, degeneracy, irreversibility, increasing disorder, increasing possibilities for newness), only the last suggests something of the creative power of the entropy principle (Hefner 1984). The overall sense of the others is predominantly negative, revealing an attitude toward the course of events in time that is drawn more from personal experience than from thermodynamics per se, but which nevertheless appeals to thermodynamics for lawlike justification. Immanuel Kant's remark, "percepts without concepts are blind; concepts without percepts are empty," seems apt here (Hefner 1984).

Percepts are formed sometimes under very dim conceptual illumination and seek out ordered frameworks by which to support and nourish themselves. Thus, the perceptions of decay and of the hopelessness of personal struggle against the ultimacy of time have to a degree inhabited the concept of entropy, giving it a mask of death; conversely, the concept of entropy, drawn from the formalism of thermodynamics, has assimilated these perceptions and elevated them to the status of law. If we are looking for the concept of entropy to supply a value-free model to illuminate the moral domain, we are on hopeless ground. It seems more fruitful to seek the common existential ground for both within the uniquely Western conceptions of the human agency in the natural order, where tendencies toward sin and disorder are perceived as natural motions the virtuous life must struggle against.

The theme, as Hefner points out, goes back to Plato (Hefner 1984). For Plato, whatever order nature has is due to its participation in a realm of fixed forms, which in the *Timaeus* creation myth are impressed by God into a protomatter whose behavior is intrinsically without order. Disorder is thus part of the givenness of things, against which God must act to create a cosmos or ordered whole. The active role of God in creation from ingredients over whose natures he has no control sets the stage for the triune Platonic ontology in which soul is conceived as the self-active ordering agency that mediates between the bruteness of matter and the ideality of forms. The cultivated soul of the philosopher is one capable of aligning life teleologically with the forms in the face of material-appetitive drives towards the idolotries of wealth, power, and so on. In this view, the struggle against disorder is the primal human responsibility, the essence of life's ethical dimension.

Two opposing and dualistically separated principles of change are seen in the Platonic cosmos. One, which we will provisionally call entropic, regards the tendency of material nature to drift toward disorder. The other, an antientropic "striving for form," marks the essence of Platonic teleology. It is expressed archetypically and perfectly by God in the act of creation and recapitulated imperfectly by

human beings in moral decision and ethical orientation. This basic theme reverberates through man's dual nature, as understood in medieval thought, and into contemporary attitudes towards entropy.

The degenerative images associated with the entropy principle are philosophical bequests from a dualistic Platonic cosmos which saw no ontological connection between the dissipative and the creative. But in truth, there are no separable entropic and antientropic tendencies in nature. There is only the entropic, which feeds on thermodynamic potential (loosely construed as order) for the generation of structure and organization.

Polarities and Balances

The Platonic cosmos inherited by the Christian West, in spite of its genuine insights into the nature of the moral as a teleological orientation from the particular to the universal or from the given to the ideal, was ill-disposed to an understanding of natural creation. In a world of fixed forms, processes that were random or adventitious could never generate anything of value. Since the good was not linked to natural process, the Platonic dualism of matter and form provided the ontological ground for a leitmotif of conquest and denial in Western ethico-religious thought, where the disorderly, the evil, might be banished from the cosmos by righteous living. Alan Watts remarked that "by and large Western culture is a celebration of the illusion that good may exist without evil, light without darkness, pleasure without pain" (Watts 1975, 48). Watts goes too far in this assessment, but nevertheless captures a measure of truth. A self-organizing cosmos into which physical and existential ingredients fit coherently requires polarities rather than dualities. The modern conception of the entropy principle has this polar character, and its dissipative operation is the means by which the creative potencies of material nature are explored in time.

The concept of entropy is quite commensurable with the Western view of time as irreversible and cosmically significant. Yet the most instructive images on the indissoluble polarity of creation and destruction appear in the Eastern religions, where time is not at all the medium of human destiny and where good and evil are strictly matters of local human perspective. In Eastern views, the emphasis shifts from a transcendent God organizing nature from the outside to an immanent God whose own nature is inseparable from his creation. In Taoism there is no "God" at all, but a rhythmic balance of polar forces, of which good and evil are but transient and parochial manifestations. Lao Tzu writes:

> When everyone recognizes beauty as beautiful,
> there is already ugliness;

When everyone recognizes goodness as good,
there is already evil.
"To be" and "not to be" arise mutually... (quoted in Watts 1975, 48).

This theme of cosmic balance and the circumscription of individual destinies it imposes runs strong in Greek thought as well. One sees its earliest metaphysical expression in Anaximander's teaching of an evolutionary cosmos in which the physical world differentiated in certain balance and measure (e.g., hot = cold) from a great *apeiron*, or boundless ground of being (Cleve 1969, 144-65). The similarities of the *apeiron* to the Tao are considerable, but one sees in the former suggestions of that characteristically Greek tension between individual destiny and universal law. Time ruled the Anaximanderian cosmos, and all individual substances had to make eventual atonement to the *apeiron* for the injustice inflicted by their separation from it. This usage of "injustice" and "atonement" is of course metaphorically substitutive for denotative vocabulary, but it conveys quite clearly a sense of the inviolability of cosmic balances in time.

While bound by these blind necessities, the world of nature is subject to its own proximate causes as well and the realm of human activity to its own interests. The human contest with the large-scale necessity of things is of course the stuff of tragic falls. Eastern views downplay this struggle into a biperspectival game: selfhood is always transient and contextual, a briefly budding flower to be enjoyed but not wallowed in solipsistically. Hinduism specifically enjoins us from tragic indulgences: In all his representations as the many-armed divine juggler, the Hindu Godhead Vishnu is always depicted as holding one hand in a gesture of calm—after all, it is only a game played in a world of appearances, where each death is but the occasion for new birth (Watts 1975, 69).

The title of this essay is taken from a Hindu conception of creation, which seems in many ways a useful metaphor for the operation of the entropy principle in the universe's evolutionary differentiation. In Hindu religion, nature is conceived as the elaborate and changing mist of a great creative breath or *paramatman*. In mythical treatments this breath flows rhythmically through two aspects of the Godhead: Brahma the creator and Shiva the destroyer. There is no dualism in this distinction—only a recognition of polar aspects to a unitary act. The breathing in of Shiva is quite literally an inspiration, a gathering up of the world's various manifestations for yet new expressions in a subsequent expiration of Brahma. Creation and destruction are thus but kaleidoscopic shifts in the world of *maya* or appearances. In this, as in Taosim, a certain balance of what we parochially perceive as good and

evil is maintained; but finally, there is only one Supreme Self to whom all being must be referred.

The Entropic Exhalation

The evolutionary differentiation of nature is a kind of entropic exhalation, a breathing out of new forms under the dissipative demands of the second law and the constraints imposed by nature's various forces. Indeed, entropic dissipation can be regarded as the breath of Brahma, the means by which the diversity of nature is made manifest.

In a cyclic universe of alternating periods of explosion and implosion, one can regard the creative potency of the Brahman breath as deriving from a prior Shivan inhalation of nature's material expressions into thermodynamic potential. We might indeed hope for these one-to-one correspondences between mythical representations and the understandings of science, but we by no means require them for the power of the divine breath metaphor to be appreciated. Even if the universe lacks sufficient mass for gravitational closure, one can still productively regard its expansion and differentiation as a great cosmic exhalation deriving from a perhaps unknowable ground of being. The driving force of the cosmic exhalation is the universe's physical expansion, which establishes a thermodynamic disequilibrium for the entropic breath to enter, carving out potential microstates for the evolutionary spread of matter-energy. The texture of the entropic breath is constituted by the cosmos's particular evolutionary unfolding.

Behind this breath, giving it form, is the law—itself part of the Godhead. It is the Heraclitean logos, "loving to hide," whose universality can never be grasped in its fullness by any of its particular embodiments. Science is our poor substitute for divine sight, by which we attempt to burn away the particularity of *maya* to the level of general being. Two kinds of ingredients are thereby revealed in the physical ontology of the cosmos, which may be given Aristotelian expression as form and potency. The universe is maintained in a condition of high thermodynamic potency by virtue of the way its matter is oriented with respect to its various forces. These forces or rules of interaction in turn belong to nature's inviolable formal structure; they give the universe its particular identity among the alternatives the imagination could perhaps conjure up, establishing allowable routes for dissipative process.

The strategy of the cosmic breath is *structuring-through-dissipation*. The word *dissipation* refers simply to the entropic process of converting thermodynamic potential to either heat or configurational disorder. Nature's forces are, with the exception of electromagnetic repulsion, associative ones. Integrative processes thus become means for dissipat-

ing thermodynamic potential. Putting two atoms together to form a molecule is a falling together of these particles into a potential energy well, which, given the vast thermal sink of space ever being created by cosmic expansion, provides for the irreversibility of such building-up or anamorphic processes in time. There is a certain ends-means teleology to this, albeit a blind one. Nucleons aggregate into nuclei to dissipate potential energy resulting from the strong nuclear force; atoms form molecules to dissipate electrostatic potential energy—and so on, through molecules, through supramolecular aggregates, through life itself (Wicken 1981). Dissipation is the driving force of the integrative tendency in matter; it is a principle of potency, a "breath" acting to bring the possible into the actual.

The evolutionary self-organization of life participates in this entropic breath in a teleological way. Living systems are organized patterns of dissipation, thermodynamic natural purposes wherein each part is at once cause and effect of the total pattern of entropy production in which it participates. Organisms not only exist through dissipation; they exist for the *reason* of dissipation as well, coming into being as stable pathways of entropy production, the breath of their own dissipation at one with the breath of the cosmic flow.

Thus we begin to appreciate the thermodynamic basis for the teleology of life. As Bertrand Russell expressed it: "Every living thing is a sort of imperialist, seeking to transform as much as possible of the environment into itself and its seed. . . . We may regard the whole of evolution as flowing from this 'chemical imperialism' of living matter" (Russell 1927, 27). The source of this chemical imperialism is dissipation through self-organization: living systems and their propagation provide particularly stable and powerful patterns of entropy production to the biosphere, and they selectively accumulate according to their abilities to participate in the irreversible flow of energy from solar radiation to the sink of space. Simon Black expressed it this way: "It has been tacitly assumed that life processes have a primary objective: the propagation of organisms. Energy is perceived as subserving this objective, and it seems strange that it should be thus diverted from its degradative tendency to a constructure role. But if the picture is inverted and the primary objective of life processes is assumed to be energy dissipation, and the evolution of organisms is perceived as arising secondarily to subserve this primary function, then life appears consonant with all other natural processes, which perform a predominately dissipative role" (Black 1978).

Again, one sees the polarity of creation-dissipation. The importance of Shiva, the fire-destroyer, to the creative process is amply celebrated in Indian mythology. I quote here from Arthur Peacocke:

Within a fiery circle representing the action of material energy and matter in nature Shiva Nataraja (as "he" is called in this aspect of his being) dances the dance of wisdom and enlightenment to maintain the life of the cosmos and to give release to those who seek him. In one of his two right hands he holds a drum which touches the fiery circle and by its pulsating waves of sound awakens matter to join in the dance; his other right hand is raised in a protecting gesture of hope—"do not fear"—while one of the left hands brings destructive fire to the encircling nature, and this fire, by erasing old forms, allows new ones to be evoked in the dance (Peacocke 1979, 317).

To be sure, there is an aspect here of the divine juggler, the master illusionist operating in the world of *maya*. But there is recognition too of the dynamics of creation, which requires the prior loosening of matter from its old bonds. In the limited sense of its cyclic connection to the Brahman exhalation-expansion, this breaking loose of old forms suggests a cosmic implosion, with matter and kinetic forms of energy being consumed into undifferentiated thermodynamic potential as a precondition to another universal exhalation. Perhaps such will come to pass. But the metaphorical power of the above image lies in its recognition of the polarity of creation involving dissipation as its dynamic partner in process. In the entropic world, creation and dissipation do not come in cycles, but are conjoined aspects of a unitary process, a single breath.

This presiding image of fire as a power of transformation is essential to understanding the creative power of the entropy principle. Inside Shiva's ring the fire is creative; outside it is degradative. The entropy principle has just this kind of Janus-faced character. One sees this fundamental understanding in Heraclitus's dictum: "all things are an exchange for fire, and fire for all things." It is essential to hold this polar unity of creation and entropic dissipation carefully in mind, because the Western picture, drawn from an historical confluence of Plato, medieval Christianity and classical thermodynamics, has so colored our feelings about the entropy principle that creative processes, especially those involving the self-organization of life, seem out of synchrony with the ordinary flow of things. Indeed, the Platonic perspective has historically inspired vitalistic solutions to the problem of life, special integrative principles that run counter to, or at least independent of, the second law. Lecomte du Nouy's popular book, *On Human Destiny*, is a good example of this latter-day Platonism: the entropy principle is taken to be very apotheosis of materialist science which must be balanced by the volitional action of God to account for the upward movement of evolution (du Nouy 1956). But when dualisms are cemented into polarities, such notions are obviated. The second law creates within a *logos* of allowable forms, making some potential structures manifest as opportunity provides.

Chance and Necessity

The problem in depicting the entropy principle as disordering or (worse) disorganizing alone is one of incomplete perspective that sees polarities as dualities. There is a special problem as well, indiginous to the evolution of materialist thought itself, in which matter is understood as brute, inert, insentient—a perspective imposed by a scientific method that has sought clarity in Eleatic fashion by suppressing the creative action of nature into clear and distinct forms of mathematical representation. This is the Cartesian cosmos, and life seemed so utterly alien to it that René Descartes was metaphysically (as well as religiously) required to posit a separate *res cognitans* or thinking substance that inhabited human brains (animals being only machines) to give them judgment and self-determination.

Such a bifurcated ontology might at least be entertained in a strictly creationist cosmos but not in an evolutionary one. Evolution requires above all that life, including its sentient dimension, should fit with the rest of nature. But in spite of this requirement, and in spite of the philosophical promise of Darwinism, evolutionary theory has not quite succeeded in weaving life into the overall dynamics of nature in ways that make it seem at home there. Indeed, Darwinism suffers from much of the hard physicalism of the nineteenth century, where matter was generally conceived as simple in a Cartesian way.

One strategy for fitting life into an essentially materialist, non-teleological cosmos is to invoke chance, in the sense of the fortuitous intersection of independent causal chains, as a prepotent creative force in life's emergence and evolution. This meta answer, responsible for much of the bad aftertaste evolutionary philosophy leaves with people who are as impressed by the sensitivity and sentience of life as by its physical adaptedness, has been spelled out in detail in Jacques Monod's *Chance and Necessity*—a manifesto of materialist biology in its most reductivist sense. For Monod, "pure chance, absolutely free but blind [is] at the very root of the stupendous edifice of evolution" (Monod 1971, 112).

Life does not make any sense for Monod; it is a fantastic accident, a felicitous coming-together of protein and nucleic acid to form a replicative mechanism, which then acts as a kinetic nucleating crystal for the elaboration of biological organization and function, including all those special abilities we like to regard as purposive in our behavioral repertories: all serve the propagation of the replicative mechanism. These two ideas—that life is a machine and that it is moreover one that emerged by chance—make life absurd for Monod in the most gloomy of existential traditions. These are both unnecessary conclusions. Chance may be blind, but it is never free; it is always conditioned by the

higher-order framework of thermodynamic law. Once one recognizes the deep connection between chance and the necessity of ordered pathways of entropy production, and the consistency within this framework of upholding the irreducibility of life's sentient dimension to materialist categories, one sees life as fitting quite smoothly with nature's dynamics and also with our own commonsense appreciations of its content. The thermodynamic cosmos is causally open, both to statistical chance and to goal-directed self-activity, in the workings-out of its particular expressions. Nature's content is evoked in stages, coevolving with causal principles that progress in discrimination from chance to goal-directed behavior to conscious decision within ethical frameworks. Each new level of discrimination flows from nature's blind teleology, serving the thermodynamic mandate for stable patterns of entropy production.

The Human Agent

Since we are special kinds of thermodynamic systems, there must be a fundamental unity between our experience of irreversibility and the prescriptions of the second law. Mythical systems provide culture-contexted ways of expressing this unity; and, like the metaphysical world views that issue from them, each mythico-religious system enjoys some fundamental insight—which however excludes it in a complementary way from enjoying others. Eastern views provide a sense of life as an expression of cosmic flow in which individual egos have their true ground of being in a deeper cosmic order. We have seen that the Hindu idea of a cosmic breath concretely expresses the polar unity of the creative process, and provides an apt metaphor for thermodynamic causation. What the Eastern views fail to provide is an adequate sense of time as the cumulative carrier of newness, in ourselves and in nature, in which progress might be a meaningful concept and in which human beings might be essential players on its evolutionary stage rather than transient configurations of the cosmic dice. Vishnu inveighs on the truth-seeker Arjuna to revel in the world of *maya* for all its worth, while leaving the grand determination of events to himself: "I am the eternal, world-destroying time, manifested here for the destruction of these people. Even without thee, none of these warriors, arrayed here in the hostile armies, shall live. Therefore, do thou rise and acquire glory" (Watts 1975, 73). A cosmic game, in which we participate but do not control.

This is not at all a teleological world in the Platonic tradition, where ethical decisions can be of real importance in the course of things. It is here that Western views, with their special insistence on the freedom of the individual to render good or cosmic havoc if he or she chooses,

seem to contain the missing dimension of our experience of time as a vehicle for self-determined change—our power of choice to make a real difference in the course of things. In an age when the world seems to be rushing headlong into, for all we know, the final holocaust of all sentient creation, this perspective on the causal power of the individual decision is crucial to hold. Watts points out that in Hindu myth the Supreme Self is not always able to predict the consequences of his own creations, that he must sometimes stand back and watch what happens to unfold from his own unanalyzable depths (Watts 1975, 88). There is some suggestion of this in Judeo-Christian scripture too: God must wait and see what becomes of his ongoing creation in human hands. The difference is that the Judeo-Christian perspective sees this not as an ever-renewing game but as one played to ultimate conclusions partly on the strength of human decisions.

There is a deep sense in which we, in our self-determining humanity, are participants in the cosmic breath—in its sentience and its moral rightness or wrongness. Self-transcendence seems a natural tendency for sentient life, since individual viability or fitness is embedded in the network of societal-ecological relationships that constitutes the world's thermodynamic flows. Life is a thermodynamic phenomenon in a much more significant way than it is a gravitational or electromagnetic one. While these forces are involved in structuring matter in special living configurations, life is nevertheless not of their nature, because time and irreversibility are not of their nature. The second law conditions the ethical realm by investing life with a dimension of temporal extension and contingency, establishing thereby the plan of goal-oriented behavior for attaining stability in time. In this, living forms, especially humans, determine nature's trajectory from the array of options available to it as a physical system.

Here the connection between biology and human values seems intimate in a different (but not incommensurable) sense than perceived by sociobiology. Normative frameworks are cultivated within the context of individual-as-thermodynamic system in nutritive interaction with a hierarchy of higher-order thermodynamic systems: family, community, ecosphere, biosphere. This holistic feature of life-in-nature makes clear the continuity between ethical values and physical tendencies. The second law implicitly prescribes a principle of competition (natural selection) among patterns of entropy production (Wicken 1980). The most stable dissipative systems, those best able to maintain a continuity of organizational type through time, are carefully organized patterns of flow in which each part is finely tuned to the operation of the whole (i.e., the natural propose). The self-serving teleology of the natural purpose is structured and constrained by its higher-order ther-

modynamic context. Ethics involves a reaching out of the self to this higher-order context; in this sense, it represents an extension, made available by consciousness, of thermodynamic selection for stable patterns of entropy production. In this expansion of interest ethics, in its broadest sense of value-laden precepts and activities, goes beyond the preservation of individuals and organizational types to an opening of nature to its highest possibilities. Thus consciousness, whose proximate adaptive payoff is biological survival, is preadapted to something far more significant—the evolution of the cosmos toward ever-greater sentient manifestation, by its capacity to substitute decision and volition for the blind necessity of survival and reproduction.

Determinism and Self-determinism

The very possibility of an ethics derives from the ability of consciousness to comprehend and choose. Here potential conflicts arise between the freedom of the human agent and the physical closure of the cosmos. The remainder of this essay will consider the sense in which the hierarchical plurality of causal relationships available to a thermodynamic cosmos removes much of the "either-orness" from this conflict. It seems indeed a measure of human perversity, in its insistence on clarity at the price of ontological content, that this issue remains to be discussed at all. Whittling nature down to that objective level of being to which mechanistic laws apply and then insisting that all processes, to be legitimately included in nature, must somehow be regenerated from this reduced causal framework is so epistemologically unsound as to scarcely require comment. Yet it does.

In the *Phaedo*, Plato has Socrates speak of the difference between the kinds of causes that govern human action from those that, for example, govern the behavior of a lever (see McMullin 1972). The former seem irreducibly connected with decisions among options the mind presents, while the latter are blind, necessary responses to impressed forces. Yet the logical necessity of the mechanical connection seems to elevate it to the level of universality in the minds of many philosophers, to the point where volition and decision are regarded as epiphenomenal, like the displays on a computer screen. Beneath it all move ineluctable mechanistic chains.

One might sigh a bit at this inversion of the *cogito ergo sum*, at the suggestion that the knower, who provides the subjective precondition for all phenomena including the intellectual construction of a "matter" to which physics applies, should then be able to dissolve him or herself into his or her own phenomenology. But in spite of our fondness for this kind of Eleatic charity, science itself refuses to knuckle under to it. While entirely commensurable with it, thermodynamic causation is

hierarchically superior to the mechanical, so that the mechanical closure of nature by no means implies its mechanical determination.

There is of course a long tradition in philosophy of covert mechanical determinism that goes back to Greek atomism and finds paradigmatic expression in the Laplacian notion that if we could but know the positions and momenta of every particle in the universe (its configuration in phase-space), then we could banish entirely uncertainty from time, and blithely predict or retrodict its course of events with complete confidence. Quantum mechanics has much to say about the feasibility of this program, but even granting it some limited validity within quantum tolerances, one must wonder what microscopic determinism might conceivably have to do with the explanation of phenomena, the stuff of experience. Democritus was not insensitive to this problem, and he tacitly admitted that there could be no science of phenomena but only philosophical commitment to a way of truth, which involved a recognition that the ineluctable motions of atoms in the void brought about all things. The contribution of thermodynamics to this matter is its provision of a general science of the macroscopic and its contextualizing of microscopic motions (in statistical thermodynamics) within a higher-order causal framework of entropy production.

Hence, a two-tiered hierarchy of causal principles operates in all natural processes, mechanistic or quantum-mechanistic laws at the level of microstructure and thermodynamic laws at the leve of macroprocess. Obviously these two kinds of causal principles must have something intimately to do with each other; the question regards the nature of their connection. The answer to this question is important, because it conveys the manner in which the universe is causally closed, or if it is causally closed at all. If thermodynamic relationships are just a macroscopic expression of an autonomous mechanical microstructure, then we do indeed have a rather boring, deterministic world in whose temporal unfolding we are really very much spectators, our feelings of self-determination notwithstanding.

But this hypostatization of billiard-ball physics has no basis in reality, even bracketing quantum objections. It is the macroscopic, the phenomenal, that controls the microscopic, not vice versa. Microscopic motions are not conserved in nature; they are generated and absorbed through chemical transformations which constantly exchange potential and kinetic forms of energy. Batteries of microscopic motions are brought into being in a chemical conversion that have no mechanical antecedents whatever and that are constrained by their macroscopic contexts.

Consider the so-called Benard instability (Haken 1977, 7). A temperature gradient is applied to a layer of liquid such that random molecu-

lar motions conduct heat upwards through the medium, just as we would expect in the absence of macroscopic constraints. But if this temperature gradient is allowed to exceed a certain threshold value, highly structured convection patterns develop with molecules moving in coherent fashions. The material nature of the medium intervenes here between efficient cause and structured effect, such that the liquid is ordered according to its own character rather than by impressed mechanical forces. This idea of a material nature, a carrier of phenomenal individuality, is an essential concept from Aristotle's thought, used by him to criticize the mechanist excesses of his atomist predecessors. It remains no less valid today. One cannot derive ordered phenomena, the units of individuality, from blind motions. Motions are not blind in such phenomena; they are always conditioned or informed by macroscopic context.

Determinism remains in this scheme, but it includes an ingredient of self-determination by a material nature that impresses its own identity on whatever processes proceed through it. Mechanical closure, to the extent that it applies in nature, does nothing to alter this conclusion. Laws of mechanism only set rules for material process; they contribute to nature's logos—to which all processes must conform and, indeed, which gives all processes their particularities in space and time. But in no way does this imply the causal sufficiency of mechanism to account for the occurrence of such processes. Mechanism is brought into play only when a given macroscopic transformation is turned on through chance or through decision.

One gets a sense in this of an ontologically coherent nature where the conscious agent causally collaborates with physical laws to bring about certain processes while denying others, and also a sense that participating in a "cosmic breath" is a notion that carries some real significance. The openness of thermodynamic causation allows us to talk in a teleological way about ends and means, without invoking a Platonic world of fixed forms, as well as about causes and effects. Structuring is a means for dissipation; self-organization is a means for establishing stable patterns of dissipation. The complex, self-referential patterns of dissipation that are living systems are stabilized by adaptive strategies that involve their acting on environments in discriminating ways. The very possibility of this informed self-activity, particularly as expressed in higher organisms, depends on an inner, "sensitive" dimension of nature through which environments can be subjectively represented as configurations of sensations, ultimately in a conscious way. To attribute the rich teleological interdependency of sensation, self-activity, and physical law to a chance coming-together of brute (i.e., exteriorized) matter seems an utterly fanciful insistence on the timeless clarity of

geometry in a complex and temporal world whose ontological content must be unfolded or discovered through evolutionary invention.

Thermodynamic-evolutionary teleology, expressive of a source of being that reveals itself progressively in nature, bears little similarity to that teleology dominant in the Middle Ages and so correctly rejected from the epistemology of modern science. So, although we are denied a simplistic natural theology whereby the order of nature can be regarded as directly revelatory of God's plan, the tying of life to an ontologically complex nature by thermodynamic flows opens us up to far richer and more subtle theological possibilities, which would seem to offer renewed promise of making science and religion partners, rather than antagonists, in investing the human condition with meaning. The metaphorical vitalization of nature as a cosmic breath provides a sense of God's immanence in a process of creation that is ongoing rather than completed at a stroke. In the latter, God can only retreat from the dynamics of the universe either to an irrelevant deistic remove or to that of a miraculous intervener in the order of things.

The challenge to theology from the other shore is to prevent divine immanence from collapsing into pantheism. The cosmic breath in which nature is conceived as both effect and participant holds an image of God as the ultimate polarity of immanence and transcendence—always more than the sum of its manifestations, always the deeper ground of being from which individual beings derive their existences. Science understands this (abstractly and incompletely) as the unfolding of dissipative possibilities according to a logos that "loves to hide" beneath its material manifestations, but into which science accomplishes ever deeper penetration. Nature's forces or rules of interaction give it a general *Bauplan* for form (e.g., the orthogonality of wave functions that specifies the microstructure of matter). But beyond this the particularities of nature's expressions must be explored in time through the opportunities and choices to entropic dissipation that become available to it.

In the Hindu world view all this could be taken as aspects of God's nature, with creation made divinely proximate in the rhythm of the cosmic breath. In the Judeo-Christian tradition these considerations invest the problem of the reality of moral choice vis-à-vis the omniscience of God with a measure of theological openness. Omniscience requires a transcendence of time, which is perhaps a contradiction of concepts. Biological time, involving as it does a cumulative, self-determining movement through options the world presents, and especially the human time that is ordered through conscious decision, would seem to be precisely that which cannot be objectified or transcended. Like the Hindu Godhead, the Judeo-Christian God must

perhaps attend with uncertainty the outcome of his ongoing creation. In a thermodynamic cosmos, time becomes more than a passive interval between events, which a Laplacian Divine Calculator could in principle deductively unfold into the indefinite past or future. It becomes rather the very medium of invention, the carrier of individuality that brings forth futures through an interaction of opportunity and decision within historically-elaborating present moments.

If God manifests himself through the creative temporality of evolution in all its aspects, a detailed foreknowledge of events is perhaps unavailable to him. Perhaps he too is bound, as was the Platonic demiurge, by the givenness of things, which includes the indeterminacy of time's productions. Or perhaps the temporality of nature extends into the very being of God, and he must await the exploration of his own unanalyzable depths through the processes of evolution and the conscious agent who brings time into cumulative, personal focus in each decisive instant. In any case, thermodynamic time, and the evolution of new forms under its aegis, suggests a nature of manifold potentialities that is open in its development not only to chance and physical law but also to conscious decisions within ethical frameworks.

One final point should be made here. The Hindu dance of creation is itself a metaphor with much room for hermeneutic meditation, since it expresses not only the play of creation, as inventive process from God's fullness and freedom of nature, but also its lawlike character, its boundedness by rules. A dance is not a chaos of activity; it has order to it, pattern and rhythm. Creation might be free, but it is constrained too by the ontological ingredients God works through (or includes in his being), such as the nature of time and the disposition of matter to interact in certain ways. For its part, chance is never free. The deck of chance is always stacked by the particular nonequilibrium conditions under which the second law operates, which impart directionality to microevents. The entropic breath thus stands above nature's processes and our participation in these processes as a metaprinciple. Through dissipation that which is potential in nature is made actual, and through the causal agencies that select and bring into being certain pathways of dissipation, law and purpose cooperate hierarchically in the unfolding of a world that is teleologically coherent without being the product of express design.

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