THE THERMODYNAMIC AND PHYLOGENETIC FOUNDATIONS OF HUMAN WICKEDNESS

by P. R. Masani

Abstract. The problem of evil is brought under the ambit of science by explicating the theological concept "sinful" in thermodynamic and phylogenetic terms, and the proposition "Homo sapiens is a sinful species" is established. By a like explication, the theological concept of the "Fall of man" is shown to be an amalgam of two concepts, Fall I and Fall II, of thermodynamic and anthropogenetic origins, respectively. Fall I affects all life; Fall II ("original sin") affects Homo sapiens and its immediate forebears alone.

The twelfth- and thirteenth-century scholastics, notably Thomas Aquinas, believed that certain issues in the realm of theology are amenable to a rational treatment unaided by faith, and that for this task theologians had to bring to bear the best available knowledge of their times. Contemporary theology has veered away from this scholastic tradition. Most modern theologians, unlike their thirteenth-century counterparts, have not striven to keep up with science, still less to lead it. Having lost touch with science, they forfeit the opportunity to bring contemporary knowledge to bear on theological issues. Accordingly, much modern theology moves in a vacuum of its own creation, with increasingly diminishing influence on modern life.[1]

It is not worthwhile today to pursue the scholastic tradition in its original formulation, for recent epistemological inquiries, notably those concerning intelligent machines, have shown that the notion of a fixed human faculty of "reason" or "unaided intellect" is illusory. We now know that there are several levels of intellectuality and learning

P. R. Masani is University Professor, Department of Mathematics and Statistics, University of Pittsburgh, Pittsburgh, Pennsylvania 15260. This article consolidates some of the ideas voiced in the Keynote Address to the Second North American Marxist-Christian Dialogue at Dayton, Ohio, 8-10 February 1980 and printed in Masani (1981). The present improved formulation reflects also the sharp criticism and useful suggestions of Dr. Karl E. Peters and his four referees, and the writer wishes to express his gratitude to them. In making the revisions he has also benefited from a long conversation with Professor Chandler Davis and a shorter one with Dr. Ashley Montagu and wishes to thank both of them very much.

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ability, embodiable in mechanisms of different types, metallic or cellular. Furthermore, we know that a rational science unaided by faith does not exist. For example, as Norbert Wiener has written:

> I have said that science is impossible without faith. . . .
> What I say about the need for faith in science is equally true for a purely causative world and for one in which probability rules. No amount of purely objective and disconnected observation can show that probability is a valid notion. To put the same statement in other language, the laws of induction in logic cannot be established inductively. Inductive logic, the logic of [Francis] Bacon, is rather something on which we can act than something which we can prove, and to act on it is a supreme assertion of faith. It is in this connection that I must say that [Albert] Einstein's dictum concerning the directness of God is itself a statement of faith. Science is a way of life which can only flourish when men are free to have faith (Wiener 1950, 193).[2]

Cognate statements can be found in the writings of Johannes Kepler, Isaac Newton, James Clerk Maxwell, Einstein, and a host of other scientists. Thus Einstein spoke of his belief in Spinoza's God, that is, of his faith in the orderliness of the cosmos. It is therefore imperative that today we redefine the scholastic goal as being one of seeking *scientific* (rather than supposedly rational and faithless) answers to theological questions.

Our purpose in this paper is to pursue the scholastic tradition, so reformulated, by bringing contemporary scientific knowledge to bear on the specific issue of human wickedness, that is, in theological terms on the *problem of evil*. We shall attempt to demarcate scientifically the prescientific notions of *human sin* (also referred to as evil or wickedness) and of the *Fall of Man*, that is, the process (actual or ideal) that brought about this state of alienation in the human species. Our demarcation will rest on contemporary thermodynamics and evolutionary theories of human phylogenesis and will center on the species: wickedness will be construed as a species attribute, not an individual one.

Most scientists look upon the concept of sin or wickedness as being unscientific; accordingly they desist from considering the problem of evil. We on the other hand will contend that the statement "*Homo sapiens is a sinful species*" is as meaningful and as verifiable by observation as any other statement of scientific anthropology, such as "*Homo sapiens is a tool-bearing species*," and that it is absurd to regard one and not the other as belonging to the domain of science. We will also claim that the emergence of mankind entailed not just an evolution of biological organization (a bigger cranial capacity, improved dentition, superior locomotion, manual versatility, and linguistic facility) but also a concurrent behavioral degradation (conceitedness, deceitfulness, murderousness, hypocrisy)—in moral terms a fall—which too it is the

duty of anthropology to expose to the fullest. Anthropologists are often blind to human degradation. For instance, Marvin Harris has written:

> By progressively severing hominid cultural repertories from genetic coding, natural selection conferred an enormous adaptative advantage on Homo sapiens—namely, the *advantage* of being able to acquire and modify a vast range of *useful* behaviors far more rapidly than is possible when genes maintain or regain control over each behavioral innovation (italics added, Harris 1980, 315).

This tells only half the story. For as human history amply testifies, the severing has also conferred on Homo sapiens the *disadvantage* of being able to acquire *useless* behavior, such as uttering nonsense, beating about the bush, crying over spilt milk, fiddling while Rome burns, and becoming greedy, Harris does not allude to this. The same unawareness marks some of the writings of Konrad Lorenz (see, e.g., citations in Eibl-Eibesfeldt 1979, 3-4). A very conspicuous manifestation of human sin is the intrinsically exploitative nature of the great majority of the socioeconomic systems that we have had since the dawn of history.

The term *original sin* has been used to refer to the beliefs that our wickedness is an *innate* characteristic acquired from Adam and Eve, or alternatively from the *ferocious* animals from whom we have risen (see, e.g., Montagu 1957, 29-34; 1968 in reference to R. Ardrey). Our interpretation of the term *original sin* is radically different: the human has *fallen* from primarily herbivorous and *peaceful* primates, and we and our Australopithicus forebears are *original* in our depravity, which is amenable to cultural and genetic influence. We contend that the latter is a reasonable explication of the religious ideas of the *fall* of man or *original sin* in scientific terms.

The discussion of these issues in what follows is divided into several sections:

1. On scientific explication
2. The moral aspect of the natural order; Fall I and the Second Law of Thermodynamics
3. Explication of the concept of sin
4. Fall II
5. Difficulties in the way of the deductive embedding of the theory of evil within Physics
6. The phylogenetic origins of sin
7. Fall II and the non-human animals
8. Neo-Rousseauist attitudes towards human sinfulness

A. A note on thermodynamics

In section 1 R. Carnap's concept of explication is recalled and the difficulties in explicating the idea of sin are described. In section 2 we

explain why to a moral individual the natural order, marked by strife and catastrophe, appears to fall short of the ideal order and constitutes a "fall" (Fall I), but we point to and accept Augustine's position that these aspects of nature better *not* be deemed as evil. In section 3 we explicate the term *sinfulness* or *evil* after a preliminary but lengthy description of human folly and show that Homo sapiens is sinful but that the Elephant, for instance, is not. From a moral perspective this extraoffensiveness of the human order constitutes a second "fall" (Fall II) (section 4). In section 5, while affirming the importance of deducing the occurrence of Fall II from the laws of physics and biology, we show that science is not yet ready for this task and that current attempts in this direction (such as "altruistic gene" theories) are superficial and/or misleading. In section 6 we tentatively answer the question as to when Fall II occurred: about 100,000 years ago. In sections 7 and 8 we examine the current views that certain nonhuman animals are sinful, and that human sinfulness came only about 10,000 years ago with the advent of animal husbandry, horticulture, and agriculture, and find both sets of views wanting. The appendix A supplies the bit of thermodynamics we need.

In the sequel the term *man* will abbreviate "mankind" or more accurately "Homo sapiens." Likewise *he* and *his* will abbreviate "he or she" and "his or her."

On Scientific Explication

Ever since the Pythagorean decipherment of musical chords in terms of fundamental tones (500 B.C.), more and more subjects that have seemed to be beyond the ken of science have been brought under its sway. For a subject to be amenable to scientific scrutiny, little seems to be required of its subject matter beyond its identifiability by independent observers and the possibility of their concurrence on the circumstances under which different propositions will be true. (How fruitful or useful such a scientific inquiry will be is of course another question; the answer to this depends on a host of other factors that do not concern us here.)

Such a scientific inquiry has several levels. One of the most basic has been singled out by Carnap and called *explication*:

> The task of explication consists of transforming a given more or less inexact concept [the *explicandum*] into an exact one [the *explicatum*], or rather replacing the first by the second (Carnap 1950, 3).

The explication of certain concepts, used more or less vaguely in everyday life or in prescientific, informal discourse, is of course necessary for the creation of a science that is meant to encompass and

supercede these vague concepts. All the great pioneers of science have had to undertake it.

Carnap has pointed out how the problem of explication differs from ordinary scientific problems, in which both datum and solution are already perfectly formulated:

> In a problem of explication the datum, viz., the explicandum, is not given in exact terms; if it were, no explication would be necessary. Since the datum is inexact, the problem itself is not stated in exact terms; and yet we are asked to give an exact solution. This is one of the puzzling peculiarities of explication. It follows that, if a solution for a problem of explication is proposed, we cannot decide in an exact way whether it is right or wrong. Strictly speaking, the question whether the solution is right or wrong makes no good sense because there is no clear-cut answer. The question should rather be whether the proposed solution is satisfactory, whether it is more satisfactory than another one, and the like (Carnap 1950, 3-4).

Carnap has also pointed out that we must come to some preliminary agreement on the explicandum, imprecise though it be, by means of examples and explanations before we can turn to the determination of its explicatum. For instance, the colloquial term *fish* has at least to be understood, say as "animal living under water," before we can even discuss a good zoological explicatum to replace it. This explicatum has turned out to be the concept, *pisces*: aquatic, cold-blooded, water-breathing gilled vertebrate with fins. It departs from the explicandum in that the warm-blooded whales and seal, which are fish in the prescientific sense of the term, are not pisces. This departure has occurred because other discoveries have confirmed that the classification of animals by habitat is not as fruitful or as significant as a classification based on their anatomical, physiological, and reproductive characteristics.

By such an analysis Carnap was able to lay down a few requirements for a good explicatum (Carnap 1950, 5-8):

1. The explicatum should be substitutable for the explicandum in most but not necessarily all cases;
2. it should be a fruitful concept, i.e. one which allows a large number of universal statements, and yields as simple a theory as possible;
3. it should be precise, i.e. introduced by means of definitions, explicit or implicit, or by less binding but equally clear-cut devices such as reduction sentences (Carnap 1937).

The explication may be classificatory (e.g., hot, warm, cold, or pisces, nonpisces) or comparative (e.g., warmer than) or quantitative (e.g., degree of temperature).

There have been important instances in science where the preliminary examination of an explicandum has suggested that no one single

explicatum is adequate for the fruitful subsumation of the explicandum. For instance, the vague explicandum "the energy or quantity of motion" gave way, after a lengthy debate in the seventeenth century, to two distinct explicata: *momentum* and *kinetic energy* (see Carnap 1950, 26). Likewise, in the calculus of probabilities, it has gradually become clear that no one exact concept of *random* can do justice to the several meanings with which this word or the word *chance* is used colloquially. Consequently there are more than one explicata for *random* (see Martin-Lof 1969).

In this paper our explicanda comprise the concept or concepts we ordinarily refer to by the words *evil*, *wickedness* or *sinful*. Our explicanda also include the notions, occurring in several religions, of an initial degradation or descent from an evil-free state—the so-called Fall. The very ability to employ such terms presupposes the ability to make moral judgements, that is, the possession of a moral sense. In an ancillary way at least, we will have to address the issue of "moral sense" as well. Thus our explication problem is much more complex and difficult than that of the transition from *fish* to *pisces* in zoology, which we brought in for illustrative purposes. We will find that a single explicatum does not suffice to capture the colloquial and theological uses of the various explicanda. For instance, the concept of the Fall will be shown to be the amalgam of two rather distinct situations, which we shall term Fall I and Fall II.

We must emphasize that what results from our explication of the concept of sin in the next two sections is science, not axiology, for no axiological premise is involved. For instance, with the definition we have adopted for the word *sinful* in (3) at the end of the section after the next, the statement "Homo sapiens is a sinful species" is factual. The term *sinful* is used as definiendum in (3), because the definiens in it is an explication of its prescientific usage among religionists. Readers may replace the term *sinful* by a more neutral one, such as *normal*, if they so choose. If they do this for all occurrences of the term in the paper, no truth-value in it will be altered. Likewise, under our demarcation of the term *moral individual* at the beginning of the following section, our assertions about such individuals are factual statements.

The Moral Aspect of the Natural Order: Fall I and the Second Law of Thermodynamics

As just indicated any explication of the notion of evil is relative to a prechosen moral scale. Thus our first task is to choose such a scale. In this we shall go by the major religions of mankind. They all proclaim the paramount importance of *concern-for-the-other*—of the maxim that

altruism promotes the human welfare whereas selfishness demotes it. Thus Dietrich Bonhoeffer spoke of freedom as follows:

> in truth freedom is a relationship between two persons. Being free means "being free for the other," because the other has bound me to him. Only in relationship with the other am I free (Bonhoeffer 1976, 37).

Accordingly, we shall look upon adherence to this maxim as the hallmark of a *moral individual* but otherwise leave undefined the concept of such an individual.

Now a universal order in which the survival of any creature inexorably brings about the destruction of other creatures links survivability to selfishness, indifference, and obduracy in a way which must appear incongruous or even painful to a moral individual as we have just conceived him. But, as simple observation reveals, the natural order of the universe around us is indeed of the type just depicted. This order in itself represents, from a moral standpoint, a degradation (or "fall") which we shall speak of as *Fall I*. Fall I does not refer to a temporal process but rather to the contrast between two states, a nonexistent one which a moral individual would find congenial and an actual one which he finds incongruous. It is in this sense that Fall I is meant to capture to an extent the prescientific, traditional concept of an initial moral descent or fall.

As a statement of science, Fall I asserts that it is the morally incongruent state that is actual; more fully it asserts that

> *In the universe, the survival of any biological organism brings about the destruction of some other biological organisms.* (1)

This proposition is easy to verify by observation as we all know. But it is also deducible from the laws of thermodynamics, a neglected circumstance but one that is germane to our inquiry. The link between (1) and thermodynamics is provided by the concept of *entropy* in its statistical mechanical interpretation as *disorder*. The following informal remarks are designed to show this.

We all know the great effort it takes to build a jigsaw puzzle, the little to knock it out. It takes little effort to mix salt and sugar, enormous effort to separate them. Briefly, external energy is needed to increase the organization of a system. So if the system is insulated, that is, made impervious to external energy, its organization cannot increase. But in actuality it must decrease, for the heat in the system creates a totally chaotic molecular movement which continually disrupts the systematic flow of matter and energy that constitutes an organism, for instance a living body. The only way to counter this steady disruption from the molecular world is again by the use of external energy. The following version of the second law of thermodynamics gives a more accurate

rendition of this assertion, the entropy concept being a quantitative idealization of our everyday notion of disorganization, much as temperature is a quantitative idealization of our ordinary notion of hotter and colder.

> THE ENTROPY PRINCIPLE.[3] *In every transformation in nature during which a system X remains thermally insulated, the entropy (i.e., internal disorder) S_X of X increases. If the transformation is prolonged sufficiently, S_X will attain a maximum, and cease to change thereafter.* (2)

Let us call $-S_X$ the *negentropy of X* and think of it as a measure of the orderliness or internal organization of the system X. We may then reenunciate the principle (2) by saying that *the internal organization $-S_X$ of a thermally insulated system X decreases.*

Principle (2) does not of course prohibit the decrease in the entropy S_A of the system A in transformations during which A is in thermal contact with its environment E. Let A be such a system in energy contact with its environment E, and let the composite system X made up of A and E be insulated from the rest of the world. The entropy principle then tells us that the entropy S_X must increase. But it does not rule out the possibility of a transformation in which the entropy S_A of A decreases, and this decrease is compensated for by the greater increase in the entropy S_E of its environment.[4] Such a transformation can take place if A possesses mechanisms for "ingesting" the negentropy (or orderliness) of the environment and for converting this into energy to sustain and enhance its own organization.

Now biological organisms do indeed possess such mechanisms. A living cell survives only within very limited intervals of temperature and pressure. Unlike a substance such as water, which can increase its negentropy by cooling, the cell maintains or enhances its organization (negentropy) by metabolism, that is, by a sequence of chemical reactions in which "chemical fuel" ingested from the environment is broken down into simpler substances and the released energy is made to raise the negentropy of the cell. Animals, for instance, feed upon highly ordered foodstuff molecules. By the processes of ingestion and catabolism, and of respiration, these molecules are converted into smaller molecules (e.g., carbon dioxide or water) of lower negentropy than the starting molecules, and these are released back into the environment. The net effect is to increase the negentropy of the animal at the cost of enhancing the entropy (or disorder) of the environment. This principle applies to all living organisms. In E. Schrodinger's words, "the device by which an organism maintains itself stationary at a fairly high level of orderliness (= fairly low level of entropy) really

consists in continually sucking orderliness from its environment" (Schrodinger 1946, 75).

As long as there is a constant input of fresh highly organized matter (complicated organic compounds) and a constant output of entropy in the form of heat and work, the organism maintains its steady state of life. But if these fresh supplies are cut off or the output of entropy becomes clogged, its own entropy will rise, and eventually it will die.

After this explanation it is easy to see how the empirical proposition (1) follows from principle (2). First let A be a herbivore, say a calf, and let its immediate environment E comprise pasture and air. Assume that the system X made up of A and E is thermally insulated from the rest of the universe. As we just saw, under the entropy principle (2) the calf can live and grow, that is, enhance its own biological organization, only by diminishing the negentropy of E. This it does by feeding upon the grass, and after degrading it to simple sugars (i.e., "robbing" it of most of its negentropy), returning it to E in the form of excreta. If the calf depletes E of all its pasture by continual grazing, it will starve, its own organization will diminish and eventually collapse. To get a better fit to the facts, we must take into account the fact that the composite system X is not insulated, but actually exposed to sunlight. But the presence of solar radiation merely slows the downward trend; it does not eradicate it.

Next, let A be a carnivore, say a tiger, let its environment E include a set of small animals, say goats and sheep, and again assume that the composite system X is insulated. Then the tiger can survive only by feeding upon the negentropy drawn from E, which (since its digestive mechanism can only digest animal flesh) means killing and eating the smaller animals.

This deduction of (1) from (2) clarifies how strife, violence, killing, and death are involved in the very process of life. Indeed, such destruction and killing are essential ingredients of the very homeostasis that sustains the ecological balance within a biotic community. For such homeostasis depends on a flow of negentropy from the lower to the higher tiers of the food pyramid, and this flow involves killing, ingestion, digestion, and excretion. For survival, the animal at tier $n+1$ has to kill a certain number of animals at tier n, and an animal at tier n has in turn to kill a certain number of animals at tier $n-1$. Charles Darwin's bumblebee example is instructive. The size n_1 of the bumblebee population is positively correlated to the availability of red clover flowers, and negatively to the size n_2 of the field mice population that attack their nests. In turn n_2 is negatively correlated to the size n_3 of the population of mice-eating cats. The negentropy of the nectar is thus passed on from the clover plant (tier 0) to the bumblebee (tier 1),

thence to the mice (tier 2), and finally to the cat (tier 3); and the last two of the three transitions involve killing.

Such thermodynamically necessitated killing can only stop when all life has ceased to exist. Heraclitus, the aphoristic philosopher of the sixth century B.C., had intuitively perceived the inevitability of this situation and of its moral incongruity when he wrote "*Homer was wrong in saying 'Would that strife might perish from among gods and men.' For if that were to occur, all things would cease to exist*" (italics added, Wheelwright 1959, 29). As we have seen, thermodynamic laws entail that without strife all *life* must cease to exist. But to a Homer or other moral individual this situation is painful, and he or she longs for a more live-and-let-live type of regime devoid of tooth and claw.

Our discussion so far has been premissed on the definition of the moral individual as one for whom the maxim of concern-for-the-other is paramount. The conceptions of moral incongruity and Fall I we arrived at depended, however, on an interpretation of this maxim that stressed the inevitability of strife in the course of survival. We would arrive at a somewhat different version of Fall I, that is, of proposition (1), were we to take into account the destruction of life caused by accidental and calamitous factors such as drought, fire, flood, and earthquake. Fall I would again affect all life and the reality it represented would again reflect natural laws, now including meteorology and geology as well as of thermodynamics and metabolism.

The philosopher Gottfried von Leibnitz spoke of the life-destructive factors we just described as *natural evil*. Augustine of Hippo on the other hand desisted from using the term *evil* in so broad a context. He attributed our bafflement at such factors to our own ignorance of them, due to limitations of our own intelligence and wisdom; and he recommended study and inquiry, not hapless impotence. Augustine's position has been admirably summed by E. TeSelle. Speaking of the things that Leibnitz called natural evil, TeSelle writes

> but Augustine . . . views them as a challenge to man to acquire knowledge of the workings of nature and put it to constructive use. His illustrations often seem to be derived ultimately from the edifying discourses of the Stoics: We are like visitors to a forge, surrounded by unknown implements; we feel resentful if we are hurt in falling against a furnace or a sharp tool, but the smith knows the usefulness of each one of them, indeed, it is only with their aid that he can do his work (De Gen. c. Man., I, 16, 25-26). The venom of scorpions is poisonous, but it is not evil in itself, for it can be put to medicinal use by someone who knows its properties (De mor., II, 8, 11-12; De civ. Dei, XI, 22). For the rest, Augustine urges men to live according to a pluralistic view of the world and simply appreciate the intricate structures and the well-adjusted behavior of all things, without reference to the inconvenience or discomfort they may occasion us (De civ. Dei, XII, 4) (TeSelle 1970, 216).

Thus, in regard to earthquakes, Augustine would advise us to study geology, find out their causes, try to predict their occurrence, and plan ahead for them.

This Augustinian attitude is very much in the spirit of good science. So while we follow Heraclitus in pointing to the dilemma with which the natural world confronts the moral individual, and speak of Fall I, we follow Augustine by refraining from calling it evil.

Explication of the Concept of Sin

Affecting mankind, and almost exclusively mankind,[5] is an affliction far more sinister than the violence, destruction, and death caused by the struggle for survival or by natural calamity (Fall I). This is the affliction referred to in ordinary parlance by the words *sinful* or *wicked*, and in this section we shall try to explicate the underlying concepts. Following Carnap's advice we shall first explain by means of examples what it is we wish to explicate. This initial explanation will occupy the bulk of this section, for wickedness is not an easy notion to demarcate.

The word *sin* is often applied to acts such as incest, which are tabooed by moral or divine law. It is not this usage of the word, in which the focus is on the individual's violation of a taboo, that we shall explicate. Rather, what we are after are the connotations of the word *sin* (or wicked) when it is used to refer to human activity that is not dictated by the struggle for survival but that is clearly inimical to the human welfare, for example, the deliberate destruction of food grain when people are starving. Such species-destructive activities that pervade human history are either absent or merely marginal in nonhuman mammalian history, and this allows us to draw a line between the human species and the others in the class mammalia. Thus the explicatum we seek (for which we will retain the very term *sin* used for the explicandum) will make meaningful and render correct the propositions

Homo sapiens is a sinful species
The elephant is a sinless species,

and assign meanings to less evident species propositions of this type, whereby their truth-values may be gauged. Keeping this explanation in mind let us consider specific examples of sinfulness, or for short, specific *vices.*

Intraspecific killing, blood-thirstiness, and conceit. When two bull elks fight for control over a harem of female elks, they fight vigorously; however, a stage comes when the weaker bull disengages and timidly

withdraws, and the victorious bull shoos him away but does not kill him. Much the same happens when two tigers compete for possession of a freshly killed carcass: there is fight and injury but rarely death. On the other hand, human quarrels, from barroom brawls to more serious disputes, often end in murder. This behavioral difference is persistent and easily verifiable. Briefly, the herbivores hardly ever kill; the mammalian carnivores kill members of species *not* their own for food; man is the only mammalian species that is regularly self-killing. (Instances of infanticide and cannibalism have been observed recently among the carnivorous mammals, including a few primates. The significance of these observations is discussed in the penultimate section on "Fall II and the Nonhuman Animals.")

The most conspicuous manifestation of this homicidal propensity in man is warfare. Human history offers notable examples of tribes living side by side in peace. But by and large, at least for the last ten thousand years, we find the prevalence of warfare. Intertribal wars were fought for possession of earthly resources (land, water, animals, minerals) often with a cruelty unknown to the beast, with total extermination of the defeated.

Irenaus Eibl-Eibesfeldt has described a contemporary instance of one such war among Aranda tribes in Central Australia. The raiders, after painting their breasts and bellies, put themselves in a pugnacious mood by singing war songs. The next morning they talk themselves into believing that they are invulnerable.

> They spend a night near the enemy's encampment and attack immediately before daybreak when everyone is asleep. Before the attack, the chieftain gives every warrior a piece of rope made of dead men's hair and places a bandicoot tail in the mouth and right armband of each of them in order to put fire into their bellies and make them better able to strike down the enemy. Each warrior paints a thin stripe on his brow and the sides of his nose. Then they creep up to the enemy's camping place and surround it. First, crying "Wai, wai, wai," they spear the sleeping men. Then, crying "Kukukukuku," they kill the women with cudgels, and finally, they deal with the young children, grasping them by the feet and smashing their heads on stones or on the ground. After completing this murderous work, they slit open the bellies of the slain and eat a little of the raw stomach fat. They make a circle around the slain and leave them, unburied. At a water hole they wash the blood from their spears, and the young warriors drink the mixture of blood and water to make themselves strong (Eibl-Eibesfeldt 1979, 173-74).

Edward O. Wilson has described how the Mundurucu headhunters of Brazil, who were peaceful, fair, and even altruistic in their internal social affairs, refer to the non-Mundurucu tribes, whose heads they hunted, as though they were animals—peccary and tapir (Wilson 1978, 113). As many such examples show, man learned to treat human beings

outside his own group and all other animals with contempt. With man was born a new vice, *conceit*.

With the growth of the division of labor, of social inequality in the copper age, individual tension and violence permeated within the tribe itself, resulting in petty fights, murders, and the imposition of capital punishment. With further growth of the population, sharper division of labor, greater gulf between rich and poor, and improved technology, the tempo of violence increased. The manufacture of weapons of torture and of death became a conspicuous craft, and the group of professional killers, on whom was thrust the job of using these weapons, a conspicuous occupation. This killing industry is dependent on man's tool-bearing abilities and high intelligence. The overwhelming proportion of human-inflicted death or torture involves the use of scientifically designed weapons. And the more our Rutherfords and Einsteins uncover the laws of the cosmos, the more devastating becomes our weaponry.

Eventually killing became a sport, for the violent urges of the populace demanded attention. In some of these sports, such as the gladiator-animal fights of ancient Rome, man not only demeaned himself but the beast as well. The latter's violent instincts were deliberately stirred up in order that the spectators could have their thrills. Thus man learned to treat the rest of nature with the same contempt and conceit with which he treated his fellow humans. By any reasonable standard, the elephant, as a species, is a more human animal than man.

Civilization has heightened the vice of conceit that was born in the course of primitive tribal competition. An example is provided by the fate of the Tasmanian aboriginals: "The British settlers who began arriving in the early 1800s regarded the Tasmanians as something less than human. They were only little brown obstacles to agriculture and civilization. Accordingly, they were rounded up during organized hunts and murdered for slight offenses" (Wilson 1978, 173). The settlers "shot at sight" these people and "put out poisoned meat for them to find" (Wells [1920] 1950, 783). Variations of the same genocidal theme were played out in different parts of the world, for example, by the Spaniards against the American Red Indians, and the Belgians against the Congolese. Slavery wore its ugliest garb no sooner than the early nineteenth century. With further progress, industrial technology was brought in to secure efficient genocide; witness Auschwitz.

Exploitation, avarice, and cowardice. The mammalian world operates only by the laws of physics and biology. The only inequality it knows is that ordained by natural law, and the only killing it suffers comes from struggle, overwhelmingly interspecific, for access to limited metabolic

resources (vegetative or animal) in the ecological environment, or from natural calamity. The human world is confronted not only by the laws of physics and biology but also by man-made rules governing social and economic life.

Now many primitive economies are devoid of exploitation. (See the section on "The Phylogenetic Origins of Sin" below.) But from the perspective of human history, at least over the last eight thousand years, such harmonious social groupings are clearly the exception. The overwhelming bulk of our socioeconomic systems are marked by wide gulfs between rich and poor, social injustice, and the exploitation of man by man. Exploitation can occur in various forms, but for our purposes we need single out only one:

> DEFINITION. We say that a subset X of a species *exploits* a subset Y if the members of X prevent those of Y from acquiring food, shelter, and other basic necessities of life which are not needed by the members of X, or if. . . . (3)

(We need not fill in the blanks, which are intended to cover other forms of exploitation, such as enforced idleness, child labor, slavery, serfdom, etc.)[6]

In all exploitative systems a new vice shows up, *avarice*. This is the lust for acquisition and consumption: monetary greed, gluttony, sexual cupidity, and overstimulation. Wars are now fought in order to maintain and extend the right to exploit, and to gratify avarice. In the wake of the vice of *avarice* comes the vice resulting from its frustration, to wit, *envy*.

Nurturing these vices and sustaining the entire exploitative social structure is the dumb acquiescence, torpor, and cowardice of large masses of people. The endangered animal, in group or alone, is circumspect: it runs away from intruders if it can so protect its life; but when cornered, it fights back, in team or even singly. Homo sapiens is the only mammal that surrenders its social and ontogenetic interests to bullying avaricious minorities after mere token, disorganized resistance and that masochistically condescends to its own humiliation.

Dishonesty, hypocrisy, treachery, gullibility, and impotency. The human, like the animal, wills and acts from motives closely determined by sense perceptions, that is, by the conditions in its environment. But thanks to his linguistic abilities the human formulates his motives in thoughts and concepts. His actions get cloaked under a cover of justification, which may or may not be honest. His memory also allows him to choose the moment to respond. Thus the very maturity of man's language, thought, and memory come to obscure the connection between his actions and their causes, and often to deceive the observer. The delib-

erate creation of such obfuscation and deception are the new vices: dishonesty, hypocrisy, and treachery.

Since antiquity, individuals and groups of individuals have practiced all three vices in order to gain power over their neighbors. They are strongly advocated in works devoted to the achievement and exercise of worldly power, ranging from instructive fables such as the *Hitopadesa* of India (c. 500 B.C.) to treatises such as Kautilya's *Arthasastra* (c. 300 B.C.) and Machiavelli's *The Prince* (1535 A.D.). An application of treachery, found in the Hindu Epic the *Mahabharata* (500 B.C.), is the advice offered to the self-seeker: "Whoever, pursuing his own advantage, intends to crush somebody, should follow a cautious and deliberate procedure. When he lifts his hand, ready to strike his enemy, he should accost him in a friendly way. He should address him even more gently while delivering the deadly blow. And when he has cut off his enemies' head, he should pity and bewail him" (Zimmer 1957, 110-11).

An example of hypocrisy in contemporary geopolitics is afforded by the contrasting responses of the Moslem nations to the sufferings of the Palestine Moslems on the one hand and the Bangladesh Moslems on the other. In the Bangladesh War (1971), the West Pakistan army killed about one million Bengalis and created over nine million refugees. These figures included more Moslems than "the entire populations of Syria and Jordan" (Wilson 1978, 155). But none of the Moslem nations, that were so vociferous in protesting against Israeli oppression, objected. Nor did the Western capitalist democracies. As for the Eastern socialist bloc, the Chinese backed the Pakistani action; the Soviets opposed it, but did not or could not induce their Arabic allies to follow suit.

Another example of hypocrisy in contemporary geopolitics is the uproar caused by certain groups on the recent decision of President Ronald Reagan to lay a wreath at a German military cemetary in Bitburg, because it included the graves of a few soldiers of the Waffen S.S. These groups do not want us to forget the genocide committed by the Nazis forty years ago, but voice little concern about our siding today with the armies of Pol Pot, whose government murdered two million Kampucheans in a two-year period. And they, who want us to keep hating the long gone Waffen S.S. for their brutal over-reaction to individual acts of terror in occupied countries, condescend to or even approve of a very similar policy of brutal massive retaliation practiced by the armies of Israel today. The abuse of memory for the prolongation of hatred and consequent behavioral abberation are unknown in the rest of the mammalian world.

Once again it is the gullibility and impotency of the majority that nurtures hypocrisy and treachery.

Bureaucracy. An application of dishonesty-cum-hypocrisy, given in the *Hitopadesa* and amusingly illustrated by a story about a lion, a mouse, and a cat, is the golden rule of incomplete performance: "Do your job, but always let something remain to be done. Through this remainder you will remain indispensable" (Zimmer 1957, 109). This rule is practiced today as vigorously as ever in many different ways, but nowhere as systematically as in bureaucracy. The well-known laws of C. Northcote Parkinson (1958a, b) on the endemic propensities to modern bureaucracies to create self-serving fake problems, to indulge in verbosity and to grow parasitically are modern versions of the old golden rule, but with the addendum: "Turn the work left undone into a new project requiring a bigger budget and a bigger staff."

By its robbery of time, perversion of human labor, disregard of human need, attraction to sluggishness and mediocrity and fear of initiative, and vitiating effect on human life, bureaucracy is one of the most exploitative instruments devised by man and one that may very well play an increasingly damaging role in the years to come.

An explicatum of sinful. This lengthy but far from exhaustive description of our explicanda brings within sight the explicatum we are after. We reach it by extracting from the above-listed vices those that appear to be the most consequential, easy to understand, and easy to verify:

> DEFINITION. A mammalian species is *sinful* if it exhibits the following behavioral conditions:
> (i) intraspecific killing is common,
> (ii) intraspecific exploitation is common (see (3)),
> (iii) deceptive or dishonest intraspecific communication is common.[7] (4)

This explication is unrealistic in that it is classificatory (sinful, notsinful). It should be treated as though it is partially comparative: the *more* a species is sinful, the greater the extent to which it exhibits the behavioral characteristics (i), (ii), (iii). We did not adopt a comparative explication merely in order to avoid the technicalities of partial ordering of the set of triplets (murderous, exploitative, deceiving).

This explication of sinfulness is limited in other ways as well. For instance, condition (iii) presupposes that the members of the species are intelligent enough to tell the difference between a true statement and a false one. The list (i), (ii), (iii) can of course be augmented, or even more profoundly recast. Nevertheless, the explication in (4) meets the adequacy requirements of Carnap. First, it is reasonably precise: by observing a species we can settle whether or not (or to what extent) it is sinful. Second, it captures much of what we mean by *wickedness* or *sin* in

ordinary parlance. It also captures to an extent the connotation assigned to the term by most theologians—to wit, the subordination of species-interest to selfish greed. Third, the explication is fruitful, for it refers to a condition in humankind which has molded its entire history and which distinguishes it from the other mammalian species. With this explication, the assertion "The elephant is sinful" is false, but the assertion "Mankind is sinful" becomes true. This truth does not of course characterize mankind: the human species has many important attributes besides sinfulness. But its sinfulness (as here explicated) is an absolutely cardinal trait, and no scientific anthropology of the human race can afford to neglect it.

Fall II

To a moral individual, as we demarcated him at the outset of our second section, the human order, beset by sinfulness, must appear much more reprehensible than the order in the rest of nature. Judged by the moral scale we agreed upon, Homo sapiens has therefore to be deemed inferior to all the other mammals on this planet. In theological terms this human degradation represents a "fall." This specific *fall of man* must be distinguished from Fall I which affects all life. Accordingly, we shall refer to it as Fall II.

Whereas Fall I is a manifestation of the thermodynamics of the world, Fall II is a manifestation of the phylogenesis of the later hominid species alone. Fall I does not refer to a temporal process or event; Fall II certainly does. Unless it is shown that there was a time in terrestrial history during which the laws of thermodynamics did not prevail, the extrapolation of Fall I into the past is not conceivable in scientific terms. But the extrapolation of Fall II into the past is conceivable; it merely takes us back into the history of the mammalian class on this earth. From a scientific standpoint, Fall II is expressed by the proposition that *in its evolutionary course Homo sapiens acquired sinfulness*, much as Fall I is expressed by the assertion that strife is an inevitable part of life.

To link our concepts of Fall I and Fall II with the traditional concept of the Fall, we must observe how Falls I and II affect a self-conscious hominid such as a human individual. The falls cause much affliction, confusion, and sorrow. The individual feels separated by a chasm from kin, torn by internal conflict between passions and humane yearnings, and engulfed by an evil environment that cannot be fathomed. This psychic condition of a loss of sense of species, of ego-isolation, nonfulfillment, and anxiety, referred to as *alienation* or *self-alienation*, is an important and tragic adjunct of the two falls, especially Fall II. This tragic aspect of the two falls is what religions since antiquity have traced

from a dramatic perspective. Since a human being is a self-conscious, reflecting, and relatively free creature, the opportunity he gets to lose his "sense of species" and live for himself is construed as a *trial* or a *temptation*. And the Fall is portrayed as *succumbing to the temptation of selfishness*.

In the Judeo-Christian scriptures it is this rendition of the Fall that is expounded by myth. In this myth the Fall comes from the misuse of human freedom exemplified in the Adam and Eve story (Gen. 2-3). In the Hindu-Buddhist myth it stems from the willing or unwilling sacrifice of the dragon, and his multiple rebirth into things (Rig-Veda) (see Coomaraswamy n.d., 6-9). Apparently, the Hebrew-Christian conception refers to Fall II, whereas the Hindu-Buddhist refers to both Fall I and Fall II. But as Ananda K. Coomaraswamy has shown in his penetrating analysis (n.d., chap. 1), the two conceptions can be reconciled by giving the phrase "in the beginning" (*in principio*) in Genesis and elsewhere in the Bible a metaphysical rather than a physical-temporal interpretation.

These myths cannot be dismissed as superstitions. They express humanity's intuitions of its own predicament hundreds of years before the rise of science. But the dramatic representations therein are of a situation, the reality of which is attested to by contemporary thermodynamic and anthropogenetic evidence. From these myths great literature or art can never really disengage, for they address very fundamental issues of human life. By lifting the mind from what "is" to what "might have been," and then to what "ought to be," they liberate man's imagination and creativity and open the path to de-alienation: the quest for truth, the courage to overcome, and the requisite altruism and self-abnegation (see Tillich 1977, 1-23, 97-112). The subject of de-alienation does not concern us in this paper, however (see Masani 1981).

It is worth noting that the alienational side of Fall II is not unknown to ethologists. Thus Eibl-Eibesfeldt writes:

> In the process of cultural pseudospeciation, human groups set themselves off from each other as if they were representatives of different species. The inborn aggression controls that, in man, serve to defuse aggression, as they do in the case of animals, thus work only in intragroup conflict. Intergroup conflict assumed traits reminiscent of intraspecific conflict in animals: it became destructive. This led to a conflict of norms. The culturally imprinted norm "Kill the enemy," who, as we have said, is regarded as nonhuman, conflicts with the biological norm "Thou shalt not kill" (Eibl-Eibesfeldt 1979, 168).

The process of pseudospeciation, which results in the conflicting pair of norms on killing, and in many other such conflicting pairs of norms on lying, cheating, insulting, and so on, is what we have called Fall II.

Again, Bernard G. Campbell, contrasting the spontaneity with which dogs pack hunt, performing "a cooperative activity that requires considerable discipline" and "remarkable self-control in the interests of the group" (1979, 362), with the agony with which a human being undertakes similar social tasks, writes:

> The evolution of the human condition is described as "the fall" because the author of Genesis describes the coming of human self-awareness as alienation from a state of holiness and the entry of evil into mankind. Clearly, the evolution of self-awareness brought with it a totally new and terrible situation: that human activity was to be directed, not by the straight-forward operations of an unreflecting brain that was a self-sufficient and integrated whole, but by the conscious functioning of the human mind, which can foresee the pleasant and unpleasant, good and evil, results of its actions. Self-consciousness and foresight therefore brought discord to the mind of man (Campbell 1979, 364).

It is possible to give the alienational side of Fall II a more biological rendition by adopting some ideas of Pierre Teilhard de Chardin. Following A. Weismann, he contended that animal reproduction involves the separation of cells into *germ plasm* (i.e., reproductive, or gamete-forming tissue) and *somatoplasm* (i.e., tissue for individual development such as muscle cells, nerve cells, skin). From the phylogenetic standpoint the somatic cells are mere agents to maintain and transmit the germ plasm.[8] Thus animal ontogenesis involves a certain conflict between the *phylum* or lineage (represented by the germ plasm) and the *individual* (represented by the somatoplasm).

Among most of the animals the individual plays its phylogenetic role as a *link* in species development; it retains so-to-speak its "sense of species," its independence notwithstanding. But as the animal's psyche and consciousness develop and its control over the exterior environment enhances, its chances to live for itself and to bypass the species increase. As Teilhard de Chardin pointed out, this chance "to go wrong" so-to-speak is insignificant among the prereflecting mammals, but it is "destined to take on a rapidly increasing importance in the case of man, and above all of socialized man" (Teilhard de Chardin 1966, 93). From this point of view, Fall II comes about from *the transformation from species-oriented hominid to ego-oriented man.*

Difficulties in the Way of the Deductive Embedding of the Theory of Evil Within Physics

The explication of sinfulness in (4) does not allow the construction of a theory of sin or evil that can be deductively embedded within physics (in the Aristotelian sense of the term, which embraces all the empirical sciences). Such theoretical construction demands a less symptomatic and more biologically intrinsic explication of the notion of sin than that in (4). As we are unable to provide this, we cannot at present deduce the

Fall II proposition "Homo sapiens is a sinful species" from the general laws of physics, chemistry, and biology, in the manner in which we deduced the corresponding Fall I proposition "life is impossible without strife" from the second law of thermodynamics in our second section. But a theory of evil that fits into the deductive framework of physics is necessary if we are ever to understand the place of evil in the cosmos. Its construction must therefore remain our ultimate goal.

In this section we shall explain why this goal is unattainable with our present knowledge and why attempts currently underway to deduce human sinful behavior from biological principles are liable to be superficial.

Wiener's analogy between evil and entropy (Wiener 1950, 11) suggests the possibility of scientific approaches to the problem of evil from different levels corresponding to those in thermodynamics. In the Appendix we have limited the classification of the latter to:

(i) the macroscopic level, at which macroscopic thermal variables (e.g., temperature, specific heat) are studied as such, without finer analysis;

(ii) the microscopic level, at which we seek the statistical aspects of molecular activity inside the body that determine the values of its macroscopic thermal variables.

But there is also a third, namely:

(iii) the subatomic or quantum level, at which the wave mechanics governing the elementary particles within a body are brought to bear on the molecular statistics that (in turn) determines its thermal attributes.

The three corresponding levels of approach to the problem of evil would be:

(i) the species level, at which one investigates the vices (e.g., murderousness) as species characteristics without delving into the individual domain;

(ii) the individual level, at which we study those propensities of individual members of a species that contribute to its sinfulness;

(iii) the genetic level at which one asks how genes and chromosomes affect the relevant individual propensities.

In this paper we have not gone beyond the first of these three approaches. The biological approach, which would also include levels (ii) and (iii), is unfeasible today for the following reasons.

The correlation of levels (i) and (ii) involves much more than simple summation. The temperature of a body is not the sum of the temperatures of its molecules. Indeed, the expression "temperature of a molecule" is meaningless, and an altogether different concept had to be found at level (ii) to correlate to the level (i) concept of *temperature*,

namely, *the mean kinetic energy of the molecule*. Likewise, to deal with sinfulness at level (ii) some new individual concepts may have to be discovered. This attitude is consonant with religious tradition, for it too denies any obvious linkage between overt individual behavior and individual sinfulness. The most ennobling act can become sinful if carried out from a motive ulterior to the edification of God.[9]

Scientifically speaking, as a *transducer*, that is, as a transformer of input signals into output signals, the individual animal is *nonlinear*.[10] Most of the interactions between individuals within a species are themselves nonlinear. The sin-creating interactions in particular are highly nonlinear and are subject to pressures from the subconscious layers of the mind to a greater degree than the others. Thus a scientific theory of evil at level (ii) would be in the realm of *nonlinear systems analysis*, a complex subject, the study of which is still in its infancy. More specifically, the theory of sin would fall in an especially difficult and unexplored part of this realm, namely, the statistical mechanics of an assembly of nonlinearly coupled but otherwise autonomous, learning nonlinear transducers marked by an *internal polarity*. This polarity (vaguely like that of the electric or magnetic dipole) would be the scientific explication of what we called "alienation" or "self-alienation" in the section "Fall II." Science is just not advanced enough today to allow for a fruitful theory of evil along these lines at level (ii). At present, we can do little more than surmise that the level (ii) correlate of level (i) sinfulness is in the nature of a polarity in the internal organization of the individuals.

As to level (iii) the situation is even more precarious. As Wiener pointed out in the early 1960s, the existing theory of gene-multiplication is *statical*. It has to be supplemented by a *dynamical theory of organic development* (Wiener 1962, 9; 1965, 403-4). The latter theory must explain what makes an organism retain its *symmetry* while growing (why, for instance, the two hands of a growing child have the same size at all moments) and what brings about *organic cycles* such as the alpha rhythm of the human encephalogram or the menstrual cycle with its dominating lunar frequency.[11] Such a dynamical theory of organic growth, incorporating genetical statics, does not exist at present; until this lacuna separating genetics from developmental biology is bridged, efforts to base *individual ethology* on genetics alone are premature, and even more so are efforts to base general *sociobiology* on genetics alone.

Such efforts can be useful in the cases where major sociobiological responses are genetically set, as with the ants.[12] But they are singularly inappropriate for the sociobiology of humans, whose behavior is strongly influenced by (postnatal) culture, and whose survival hinges not only on maternity as with all mammals but on extended protection,

feeding, and training by parent and community. The human being spends forty percent of his life as a learner; the insect spends none.

In brief, a scientific theory of evil at level (iii) is beyond our ken for want of a genetically based dynamics of organic growth and organic interaction.

The fundamental difference in the foundations of human and insect behavior, to which we just alluded, explains why we have confined the ambit of the problem of evil to the mammalia. We would be tearing the word *evil* too far from its traditional and theological moorings, and indulging in bad explication (by Carnap's standards), were we to apply it to a memoryless organism, devoid of a learning faculty, whose actions are genetically determined. The insect and fish seem to fall in this category, and so too to a lesser degree do the birds. We have also to note the considerable difference between the geneticist's use of the word *altruism*, in reference to a soldier ant that is genetically programmed to die after it has performed a certain species-useful routine, and its ordinary usage, say in reference to a soldier who voluntarily goes beyond the call of duty and sacrifices his life to save the lives of his friends. While "altruistic" genes[13] may promote the second sort of altruism, it seems to us that the latter may exist without the former if the influence from home, church, and school is sufficiently strong.

For all these reasons, it seems best at present to gain as much insight as possible into the nature of evil by treating its study as a part of anthropology, and only later (hopefully in the not too distant future) try to build a theory of evil that fits into the deductive framework of physics.

The Phylogenetic Origins of Sin

Since the problem of evil is not at present resolvable by a deductive route starting from the general laws of nature, we shall adopt a historical approach to the problem, that is, investigate the historical origins of sin.

Since the earlier primate species are sinless (according to our explication in (4)) it is clear that the origins of sin must lie in the period of the descent of man from these primates. Latest paleontological and genetic evidence on hominization indicates that Homo sapiens is the product of an evolution from plains-living primates of the genus Australopithicus (of the Hominidae family) that lasted about five million years. These subhuman hominids were able to defeat their mammalian adversaries by brain rather than brawn. Approximately two million years ago these man-like hominids began turning into the ape-like men of the genus Homo. We are adhering to the current (but still controversial) view according to which the fossils discovered by L. S. B. Leakey in

the Olduvai Gorge in Tanzania in 1960 belong to the genus Homo (Homo habilis) and not to Australopithicus (Australopithicus habilis).

The dietary changes that accompanied this transition must be noted. The primates are predominantly herbivorous, but by virtue of their arboreal habitat they had access to foliage, fruit, and seed of high food-value, which are denied to the grazing herbivora in the plains. The primates are also able to consume and digest animal foods, but the need for meat did not arise as long as the arboreal habitat was intact. The shrinkage of the arboreal surface of the earth incumbent on the climatic changes during the Pliocene (over five million years ago) forced the primates to venture into the plains. These "terrestrial" australopithecines, with a digestive system dependent on high arboreal protein, could not survive on the normal diet of the grazing herbivora and had to make up for the lost arboreal protein. This they did by hunting small, and eventually even large, herbivora. They compensated for their weaker physique by cooperative hunting using pebble tools, which in turn depended on their increasingly erect posture, bipedal locomotion, and their growing manual dexterity, linguistic abilities, and intelligence. This hunting improved with the advent of Homo habilis, the earliest known species of the genus Homo.

The cooperative killing of game by the clever and ever growing use of weapons gave Homo habilis, and more so his descendent Homo erectus, a considerable advantage over the other species. As Campbell has written:

> There is little doubt that the final stage in human evolution (since the Lower Pleistocene) was correlated with the exploitation by man of the large terrestrial mammals. Man's immensely successful evolutionary radiation must be associated, then, not with a fundamental change in diet, but with an important change in emphasis from a diet that was mainly vegetarian to one that was increasingly omnivorous, if not distinctly carnivorous.
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> . . . . . .
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> In leaving the forest for the plains, man's ancestors changed not only their diet but their whole way of life. The change in diet was a reflection of the new environment, not the reason for it (Campbell 1979, 209).

Such cooperative hunting of large game has several features of war. Apart from the use of weapons, there is the gathering of intelligence, the agreement on tactics, the deliberate use of deceptive signaling, and so on. Such hunting, being for food, is dictated by thermodynamic *necessity. As such it is a manifestation of Fall I. But by virtue of the* use of weapons, and of tactical planning involving pregathered intelligence and deceptive signaling, it is rather different from the pack hunting practiced by the weaker carnivora such as the wolves or wild dogs against stronger quarry. The change is in the direction of what we have called sin in (4) above.

It is not hard to imagine situations of scarcity in which two unrelated social units of these "advanced" hominides, vying for game or edible foliage over a common territory, feel the pressure to apply the techniques of the social hunt to eliminate their hominid competitors before going after the game itself. And we can conceive of cases in which one or both of the parties succumb to such temptation. The door would then be open to the spread of killing into the domain of smaller intraspecific disputes that other mammals settle by vigorous but generally nonlethal combat. In this way, units of a hominid species could become increasingly sinful, the loss of their control over the interior environment being matched by the gain in their control over the exterior, and sin would gradually permeate into the entire species.

There is no direct evidence to support what we have just depicted. But it is indirectly supported by the evidence of the cracked skulls of Homo erectus unearthed in Ngundong in Central Java in 1931 and 1933, Choukoutan, China, and other sites in New Guinea, Borneo, and Krapina (in Yugoslavia) (see von Koenigswald 1976, 148-50). The approximate dates of these remains according to Campbell (1979, 118-20) are

Ngundong:	50,000-150,000 B.P.;
Choukoutan:	350,000-400,000 B.P.;
Krapina:	30,000-450,000 B.P.

The bases (foramen magnum) of the skulls at Ngundong had been systematically widened—a task requiring the use of hand tools. It is surmised that this was done in order to gain access to the brain, which was then eaten in the belief that the dead person's spiritual powers could be so inherited.

By critical examination of the accumulated material on bone damage, M. K. Roper found that many of the injuries came from actual combat, that is, were not postmortem. A. Mohr, who confirmed these findings, found that many of the injuries were caused by stone axes and some were caused by stone arrows (see Eibl-Eibesfeldt 1979, 126-27). As further evidence, Eibl-Eibesfeldt cites the battle scenes depicted in Mesolithic and Neolithic rock drawings and paintings and also points out that battle axes found in Neolithic fortifications were unsuitable for animal hunting, that is, they were weapons of war.

This archeological evidence suggests the hypothesis that skull-cracking and cannibalism were very early hominid proclivities, and it lends credence to the hypothesis of the early origins of sinfulness.

In a recent analysis of early cannibalism T. Jacob correctly points out that hunting an outside group of hominids, who are themselves hominid hunters, would be much harder than hunting herbivores (1981, 97-100). In brief, hominid-hunting is a very inefficient mode of food-procurement. This strongly suggests that early Homo sapiens'

proclivities for head-hunting and cannibalism were confined to warfare alone and perhaps to certain rituals, but played little or no part in his routine food-procurement. (Jacob makes a case that the bone damage in the skulls was post mortem and accidental and that cannibalism was marginal in Solo Man and Peking Man. But he does not refer to the opposing evidence that we have cited.)

The question of sinfulness of the earlier species of the genus Homo or even Australopithicus, and the causes of their extinction, is also important. If Neanderthals were sinners, then it is very likely that so were their immediate successors, the Homo sapiens, and this would set Fall II at about 100,000 years in the past. Another intriguing issue is what brought about the extinction of Homo Neanderthalensis and the still earlier species Homo erectus.

J. Monod has made some pertinent observations on the causes of extinction. Without alluding to the problems caused by unavailability of arboreal protein, he has pointed out that the acquirement of rudimentary language by the hominids gave them an overwhelming advantage over their competitors and thereby created in their subsequent evolution a strong pressure towards a brain that favored linguistic development. In the initial stages this ideational factor evolved hand in hand with other physical factors.

> But as this joint evolution went forward, its ideational component could only tend to greater independence of the restraints which the central nervous system's own development gradually abolished. Owing to this evolution man extended his dominion over the subhuman sphere and suffered less from the dangers it harbored for him. The selective pressure which had guided the first phase of the evolution could then ease, in any case taking on a different character. Now dominating his environment, man had no serious adversary to face other than his own kind. Direct intraspecific strife—mortal strife within his own species—henceforth became one of the principal factors of selection in the human species.
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> . . . . . .
>
> Somewhere in the human species' development and expansion the point was reached where tribal or racial warfare came to be an important evolutionary factory. It is quite possible that the sudden disappearance of Neanderthal man was the work of our ancestor Homo sapiens. It was not to be the last performance of its kind: genocides abound in recorded history (Monad 1972, 161-62).

A more cautious view on "the sudden disappearance" of earlier species is expressed by Campbell: "We do not at present have enough evidence to determine whether the big-jawed populations were genetically swamped by the invaders, were exterminated by them, or evolved into their successors" (Campbell 1979, 112). The "invaders" or "successors" referred to is modern man.

Until we know much more about human phylogenesis during the time-span from the last 100,000 to the last 10,000 years, we cannot

definitely say when or how Homo sapiens became sinful. The available evidence suggests that sin grew with man's greater control over the exterior environment, resulting from his bipedal posture and liberated hands, high intelligence and linguistic prowess, and social cohesiveness. These factors turned Homo sapiens into a successful hunter and killer as well as into an intelligent, inventive, and freer creature. Thus human wickedness and human freedom have progressed together. Understandably, evil is not eradicable in toto by the wise conduct of individuals and has a life of its own. This thought has echoed through the ages, but perhaps its most succinct expression is in the utterance of Thomas à Becket in T. S. Eliot's verse-play *Murder in the Cathedral*, "Sin grows with doing good" (Eliot 1935, 44).

Fall II and the Nonhuman Mammals

Some recently observed instances of intraspecific killing, infanticide, and cannibalism among certain nonhuman mammals seem to contradict the conclusion in our section on "Explication of the Concept of Sin" that these mammals are sinless, and to cast doubt on our hypothesis on the phylogenetic origins of human wickedness. In this section we shall examine these issues.

We shall show that the aberrations observed stem from human intervention in the animal domain and are in reality reflections of human sinfulness. Our only conclusion from the observed malignant behavior and from more general considerations is that mankind has the power to transmit its wickedness to other animals. In short, animal wickedness is man-made.

The species in question are the lion, the spotted hyena, the langur monkey, the chimpanzee, the gorilla, and some others. We have had time to study the data only for the African chimpanzee (Lawick-Goodall 1975; Goodall, 1984), the African mountain gorilla (Fossey 1981), and the spotted hyena (Kruuk 1972).

The African Chimpanzee. (Observation period: 22 years, 1960-1982) In 1974 a large chimpanzee group ferociously attacked a smaller group, which had split off from it two years earlier. A gang of three to six attackers severely maimed one victim. The attacks, each lasting about twenty minutes, were repeated, long after the victim was rendered senseless. "Within a full year period every one of the seven males and at least one of the three females had disappeared" (Goodall 1984, 44). The attacks were malignant, marked by cruelty that is abnormal for the nonhuman mammals. It is reasonable to surmise that the genocide benefited the species by reducing the competition for food, but so far the malignancy of the attacks has not been explained.

A female chimp ("wild and indifferent") and her adult daughter killed and ate three infant chimps. The mother of the first of the three could not put up a good defense because she was suffering from polio. It is believed that the murderous mother-daughter pair killed seven more infants in the course of the four-year period, 1975 to 1979, approximately. Jane Goodall writes: "I suspect that it was an aberrant behavior first shown by the mother, and imitated by the daughter" (1984, 47-48).

The African mountain gorilla. (Observation period: 13 years, 1967-1981) Three family groups were studied by Dian Fossey (1981). Infanticide was witnessed in family groups 4 and 8, and malignant murdering in group 5. Six of thirty-eight infants born during the thirteen years of observation were victims of infanticide.

In group 8, the events leading to intergroup infanticide began when a matriarch (Koko) died, and the group leader (Rafiki) took on a new mate (Macho) and sired a daughter (Thor). Rafiki died before Thor was a year old. Leadership of the group was then assumed by Rafiki's son (Peanuts). He safeguarded both Macho and her infant Thor. But during an encounter between groups 8 and 4, his protection proved inadequate and Thor was killed by the leader of group 4.

In group 4 the events leading to intragroup infanticide began after a good deputy leader (Digit) and after some months the leader (Uncle Bert) were killed by poachers. Another, weaker, assistant leader (Tiger) took charge, but this was contested by a stronger and more aggressive male outsider (Beetsme), who had been accepted into the group earlier. As a result Tiger deserted the group and the outsider Beetsme took charge. Beetsme, a bad leader, kept attacking a female (Flossie) from Uncle Bert's harem, and her son (Frito). Finally he killed Frito—about twenty-two days after Uncle Bert's death. This was the fourth infanticide observed.

In group 5 the leader (Beethoven) and his longtime mate (Marchessa) were both old. A more dominant female (Effie) and Beethoven had a son (Icarus). One afternoon when Marchessa was resting under a tree, Icarus kept attacking her violently and dragging her body. Within half-an-hour she was dead. But Icarus persisted in attacking and mutilating her dead body. The next morning found him doing more of the same.

This malignancy exhibited in group 5 remains unexplained. With regard to group 4, it is surmised that the killing of an infant by an accepted outsider improves the mother's return to estrus and the chances of breeding a family for the outsider, thereby furthering reproduction without the dangers of inbreeding.

The spotted hyena. Hans Kruuk's study of the hyena (1972) occupies an entire book. We will focus on a few fragments of this comprehensive study that bear on malignant behavior.

Intraspecific killing, often followed by cannibalism, does occur, as does infanticide. Most of the killing is interclan and takes place when neighboring clans clash near the common boundaries of their territories. Such clashes seem to follow only when a clan assumes its role as predator rather than scavenger, scores a kill, and a neighboring clan has its eyes on the dead prey. Kruuk has explained how such fights at sites of a predatory kill can start: "Generally a clash consists of a great deal of calling and displaying and chasing, and physical contact is rarely made. But if it is, members of either side may be severely mauled or even killed" (1972, 255-56).

Explanation of these malignancies. These examples of malignant aggression within a group of conspecific mammals appear insignificant in relation to the large number of exemplifications of their many benevolent traits that Goodall, Fossey, and Kruuk cite, or in relation to man's colossal violence against man. Nevertheless, the malignancies must be explained. Before we do so it is convenient to consider the ways in which *the depletion of a group's food sources* and its necessary side effect, *a drop in the group's population*, can come about.

First, flood or earthquake could bring about both simultaneously.

Second, drought or frost may cause food source depletion, and then population drop might result either from starvation or from predation by man or beast.

Third, human encroachment on the group's feeding ranges may be the cause of food source depletion, and then population drop could follow as in the second case.

But there is another way in which population drop might occur when, as in the third case, human encroachment is the cause of food source depletion. This is suggested by two interesting observations of Eibl-Eibesfeldt on the old world monkeys:

> It is not the especially aggressive animal that reaches the highest rungs on the ladder of rank, but the especially friendly one that knows how to win the others' sympathies.... A high-ranking male must be tolerant toward young animals and allow them to play round about it. It must furthermore be a good protector.... Its status depends upon its recognition by the other members of the group, and this will be withheld from a purely aggressive animal. This is true, however, only for monkeys living under *natural conditions. In the cramped conditions of zoo life, tyrants achieve high positions in the pecking order* (italics added, Eibl-Eibesfeldt 1974, 86).

Concerning tree shrews he writes:

The females mark both their young and the entrance to the nest with the secretion of a gland on their chins. This prevents the young being eaten by other conspecifics. With mild overpopulation, first of all the function of this gland atrophies, so the young are no longer protected and get eaten. If the stress becomes greater the function of the mammary glands also atrophies; as the stress increases that of the gonads atrophies as well. The animals lose weight and die (Eibl-Eibesfeldt 1974, 235).

One may suspect that nonlinear interactions of this and other sorts play a major role in the life of many animals besides the monkeys in ways yet unknown (see the section on the "Difficulties in the Way of the Deductive Embedding of the Theory of Evil within Physics.") This suggests the investigation of a new situation in which there is *a long-term depletion of the group's food sources* as well as *a short-term overcrowding, with tyrants holding the dominant ranks*. In this situation, the side-effect of short-term overcrowding could be brought about by perpetration of murder or of maiming of the malignant sort observed by Goodall and Fossey in the chimp and gorilla, and perhaps (by dint of more involved nonlinearities) by Kruuk in the hyena as well. Thus we must entertain the possibility that *some of the observed malignant aggressiveness is man-induced.*

Some of the evidence we have lends credence to this conjecture. Fossey tells us that human encroachment on the gorilla's domain took the forms of land-clearing, poaching, illicit collection, and tourist interference (1981, 501). The damaging effects of poaching were felt most when good leaders such as "Digit" fell victim, and a vacuum was created at the top (1981, 500). From Goodall's account (1984) it transpires that human intervention in the chimpanzee's domain comprised the occupation of land by local villagers, the spread of a polio epidemic, and luring-by-banana. The last was practiced by Goodall herself to break the initial ice, but it also led to begging and scuffling, and to fights with the baboons living in the area. We may expect that other forms of intervention such as poaching also occurred.

As for the spotted hyena we read:

the Serengeti National Park is not a self-contained ecological system; *increasing settlement along the boundaries forces herbivores out of their habitat and into the national park*, man-made fires sweep the country, and poaching is rife (italics added, Kruuk 1972, 3).

Hyenas live in large communities, "clans," of up to eighty animals. However, in some areas like the Serengeti, there are such large temporary fluctuations in food supply (caused by the migration of prey animals) that the clan system is disrupted, though still recognizable (Kruuk 1972, 7).

Thus human intervention in the animals' domain reduces the range of each clan, thereby crowding the clans and raising the chances of clan

clashes and intraspecific killing. But the intraspecific violence of the hyena may be augmented by less direct effects of human dominance of the planet. The depletion of wildlife means the depletion of carrion. But we read, "If hyenas get a chance to scavenge they will take it. . . . On the whole, the amount of scavenging they do seems to depend on the availability of carrion" (Kruuk 1972, 7). So it seems that man's destruction of wildlife obliges the hyena to predate (not scavenge) more often than he would like to, that is, to climb a step on the ladder of sin.

If the hypothesis conjectured two paragraphs earlier is correct, two conclusions follow. First, it is human intrusions that disturb the delicate internal order of a species, denies it the normal route by which it can seek its phylogenetic objectives, and offers it an alternative sinful "Fall II" road towards their accomplishment.

Second, ethological observation is subject to Bohr's complimentarity principle (Bohr 1958): what is observed is not innate behavior but behavior as affected by centuries of human-animal interaction in which one partner is a sinner, and to a lesser degree by the act of observation itself.[14] Furthermore, this situation will worsen with the passage of time, for more and more human intervention is to be expected. Thus, from the strict and narrow standpoint of gauging the animal's sinfulness, such observations will become less and less significant.

The first of these conclusions is supported not just by the evidence of the three cases we have studied. It can be maintained on very general grounds. In Campbell's words:

> In the past 5,000 years man has altered the ecosystem in many parts of the world and destroyed the natural balance. Pastoralism itself has been one of the most destructive forces; it is clear that wherever it has been carried out in semi-arid regions, whether in Australia, Asia, Africa, the Americas, or in limited areas in the Mediterranean regions of Europe, there has been degradation of the grasslands and the threat or reality of soil erosion. The local fauna has been destroyed and the existing ecosystem degraded beyond the point where it can naturally equilibrate. Where soils are eroded, the loss is irrevocable. The displacement of game and the destruction of their natural environment has done far more damage to natural life than all the hunting of the Pleistocene. In the same way agriculture and deforestation for timber have involved the destruction of vast areas of forest (areas of naturally high rainfall), and we have lost both the forest with its associated flora and the forest animals (which often have a very limited distribution) (Campbell 1973, 393).

A vague embryo of the first of these conclusions is discernible in the Judeo-Christian myth of origin.[15] We read:

> And God saw that the wickedness of man was great in the earth and that every imagination of the thoughts of his heart was only evil continually (Gen. 6:5).
>
> And God looked upon the earth, and, behold, it was corrupt; for all flesh had corrupted his way upon the earth (Gen. 6:12).

Neo-Rousseauist Attitudes Towards Human Sinfulness

In this section we examine the views voiced by several noted anthropologists which (stated in our terminology) claim that human wickedness has social rather than phylogenetic origins and came only with the advent of animal husbandry, horticulture, and agriculture, about 10,000 years ago, and that the earlier Paleolithic hunter-gatherers had harmonious intraspecific relationships. We shall refer to these as *neo-Rousseauist theses*. Among these is the *Marxian thesis* that links wickedness with the birth of economic classes within the settlements and with the institution of the state.

There is much anthropological evidence that supports the neo-Rousseauist position. As Ashley Montagu has written: "In non-literate societies property is shared with the members of the group much as it is shared with the members of one's immediate family in our own society. Food is usually shared with everyone, and hospitality in such matters is usually carried far beyond the practices customary among civilized peoples. No one in a non-literate society, not even the laziest ne'er-do-well, need want for food. Such cooperation is considered a moral obligation" (Montagu 1957, 64). Speaking of warfare, he writes:

> the Australian aborigines are completely unacquainted with it. The nearest they ever get to it is in the form of the spear-throwing duel I have described, and this can scarcely be regarded as war. In fact, it is difficult to convince an Australian aboriginal that there exist peoples who make organized attacks upon other peoples in order to kill and maim as many of them as possible as quickly as possible. The Eskimos are similarly unacquainted with war as a social activity and equally difficult to convince that other peoples practice it. The Veddahs of Ceylon are another example of such a people, and so are the Bushman Hottentots of South Africa. Interestingly enough, all these are food-gathering and hunting peoples, and non-agricultural (Montagu 1957, 59).

The absence of warfare did not mean the absence of intraspecific killing, for as Montagu continues:

> Among the Australian aborigines a new born baby will be buried alive or exposed should it be born to a mother who already has a one-year-old and perhaps one or two other children. This is done because it is believed that a newborn baby is not, in fact, quite human, and so a human life is not really being taken, because it is not fair to older children to have too many young children since the mother cannot pay proper attention to them but must thin it out and share it with too many children. Bringing up human beings, the Australian aborigines hold, is a full time job. Infanticide is practiced for similar reasons among many other tribes (Montagu 1957, 60).

This view is also endorsed by Campbell: "The impossibility for hunter-gatherers of carrying and nursing more than one child at a time

indicates that a cultural adaptation such as infanticide was possibly quite common" (Campbell 1979, 388).

Aside from the possible prevalence of infanticide, there is compelling evidence that refutes the neo-Rousseauist supposition and supports the viewpoint that the Homo sapiens species was always sinful. The evidence can only be briefly outlined. Much of it comes from Eibl-Eibesfeldt.

First, as already noted, there is archeological evidence in support of the view that skull-cracking and cannibalism were early hominid proclivities.

Second, the smallness of the early populations and the possibility of peaceful dispersal over wide open spaces did not preclude warfare. For as Eibl-Eibesfeldt points out:

> hunters and food gatherers need very large territories, and conditions are not the same everywhere. Some areas are rich in game and plant food, firewood, and watering places, and other areas offer less favorable living conditions. There is not the slightest reason to suppose that our ancestors did not compete for the better areas. The archeological evidence shows that this competition was warlike (Eibl-Eibesfeldt 1979, 129).

He also points out that hunter-gatherers are (like other mammals) "territorial" with regard to their ranges; strangers of the same species are not welcome on them. He provides ample evidence to back his conclusion that "there are a large number of thoroughly warlike tribes of hunters and food gatherers who defend territories" (Eibl-Eibesfeldt 1979, 129). The Eskimos and their neighbors, for instance, could overstep hunting territorial boundaries only at their peril (Eibl-Eibesfeldt 1979, 131).

Third, there is considerable evidence suggesting the prevalence of violence among the Pygmies of Central Africa, the Hazda of Tanzania, and the Bushmen of the Kalahari, and the Aranda tribes of Central Australia, all hunter-gatherers. Some of their raids were no less brutal than the one we described among the Aranda in the section on the "Explication of the Concept of Sin" (see Eibl-Eibesfeldt 1979, 138-50).

Fourth, a good deal of evidence points to the prevalence of other evils among the food gathering and hunting peoples such as *adult homicide, conceit, debasing use of mockery and invective, and sibling rivalry*. Despite the peacefulness of the Bushmen's social organization, their personal distrust often turned their petty quarrels into homicides, which by some counts reached current United States levels (see Eibl-Eibesfeldt 1979, 157-58). The potlatch feasts (called "battles") and aggressive songs of the Kwakiutl Indians reveal the conceitedness of their chieftains (Eibl-Eibesfeldt 1979, 130). But conceitedness reached all strata of such tribal societies, a common ingredient being the con-

tempt shown for certain functions of the human and animal body. Thus in their insulting invective, the Bushmen often imputed physical defects and/or resemblance to an animal (Eibl-Eibesfeldt 1979, 159).

On the other hand, not all agricultural societies need be warlike. For instance, the agricultural village communities of ancient India were peaceful, and if one accepts Karl Marx's views ([1867] 1951, 391), they exemplified primitive communism. It thus seems fair to concur with Eibl-Eibesfeldt that "Among hunting and agricultural societies alike, there are cultures with peaceful ideals, and others with warlike ideals" (Eibl-Eibesfeldt 1979, 161).

To probe further into the neo-Rousseauist position, we must take into account the distinction between *the act of sinning* and *the capacity or propensity to sin*.[16] Frederick Engels's explanation of how economic classes came about shows that mankind's propensity to sin existed during the stage of primitive communism:

> The new system of classes is inaugurated by the meanest of impulses: vulgar covetousness, brutal lust, sordid avarice, selfish robbery of common wealth. The old gentile society without classes is undermined and brought to fall by the most contemptible means: theft, violence, cunning, treason, . . . (Engels 1884, 158).

For how could the members of a sinless society acquire such mean impulses, and how could a sinless society be so weak as to be swept away by the wicked machinations of a few? The succumbing of some to the temptation of avarice and the dumb acceptance of the resulting havoc by the majority (be it from cowardice, gullibility, bad vigilance, torpor, or indifference)—are these not two faces of the same sinful coin?

The very displacement of primitive communistic structures by exploitative ones suggests that *humans had acquired their sinful propensity before the advent of communistic tribal bands*. For these communistic bands (such as the peaceful, humble, and honest Tasaday cave-dwelling Stone Age people, discovered in the Philippines in 1971), viewed from our two-million-year phylogenetic perspective, appear to be transient phenomena brought about by metastable (easily disruptible) sets of favorable circumstances (such as small-sized bands separated by vast spaces of jungle). No sooner had the growing forces of production and accumulation of common wealth, or perhaps natural calamity, upset these favorable circumstances, than the latent sinful propensities were activated, and the communistic bands collapsed.

We have therefore to reaffirm that mankind's sinful propensity was acquired long before it settled into peaceful tribal bands, and that there is strong evidence that sinning itself, in the form of intraspecific killing, preceded the advent of such communities. *The phenomenon of sin (in both potentiality and actuality) belongs to the much earlier stage of hominization*

during which the Hominidae became Homo sapiens. The ancient religious view of the deep-seatedness of human sinfulness, far from being superstitutious, is profound.

It seems clear, however, that human wickedness received a great boost during the human settlements that marked the agricultural period of mankind. And to this extent the neo-Rousseauist viewpoints embody a considerable degree of truth—so much so that we may even bifurcate Fall II into a part A, dating to about 100,000 years ago, and a part B, dating to about 10,000. Also true is the Marxian view that mankind's sinful propensity is controllable by the socioeconomic structure of society. And we can all agree that a major task of modern civilization is the restoration of a socioeconomic order in which this wicked propensity can once again be brought to dormancy, or as near to dormancy as is humanly possible, and the more brutal laws of "civil" society can be supplanted by ones that approximate the more humane laws of the jungle that govern the "wild" society of the Elephant.

Appendix. A Note on Thermodynamics

The version (2) of the second law of thermodynamics and the entropy concept mentioned therein belong to *statistical thermodynamics*. In *classical thermodynamics* the law is enunciated in classic thermodynamic terms, and entropy is defined thereafter, again in classical terms.

The classical theory starts with the macroscopic concepts of "thermodynamic state," "diathermal wall," and "adiabatic wall." A hypothesis ("Zeroth law"), asserting that the relation of thermal equilibrium between two systems is an equivalence, then leads (via pure mathematics) to the notion of *empirical temperature*. A basic hypothesis (first law) asserts that the work done in an adiabatic transformation depends only on the initial and terminal state. This allows the introduction of two concepts: *internal energy* and *heat-gain*. The empirical evidence of the *irreversibility* of several transformations in which work is turned into heat is then made the basis of a new hypothesis (second law) to the effect that every neighborhood of a state x contains states y adiabatically inaccessible from x. This entails (by a pure mathematical theorem due to C. Caratheodory) that the Pffafian equation $dQ = O$ (Q = heat) has an integrating divisor of the form $T\{\Theta(\cdot)\}$, that is, there is a function T on the real line and a function Θ on the state space such that $dQ/T\{\Theta(\cdot)\} = dS(\cdot)$, where S is a function on the state space. The function $T\{\Theta(\cdot)\}$ is called the *absolute temperature*, and the function S the *entropy*. *Easily deduced is the proposition that the entropy $S(\cdot)$ of a system cannot decrease in any adiabatic transformation, and in all except the (purely ideal) "quasi-static" adiabatic transformations it will in fact increase.*

Statistical thermodynamics emerges when the classical thermodynamical variables are associated with certain averages that appear in statistical mechanics. The average that gets associated with the classical entropy $S(\cdot)$ is then most easily interpreted as the "internal disorder" of the system, and the last italicized statement reduces to the Entropy Principle 2 given in the second section.

The polished approach to the classical theory outlined above is due to C. Caratheodory (1909) and has been strongly endorsed by Max Born. It is lucidly presented in the books of Born (1949) and H. A. Buchdahl (1966). Lucid expositions of the transition to the statistical theory appear in the books of A. I. Khinchine (1949) and J. D. Fast (1962).

Historically, thermodynamics first made its appearance in the Steam Age, just preceeding the Industrial Revolution, thanks to the pioneering efforts of remarkable engineers such as Sadi Carnot (1824). The notion of "efficiency" of a steam engine and "Carnot cycle" loomed large in the early history of the science, and it was in these conceptual terms that the notions of absolute temperature and entropy were first introduced by Lord Kelvin (William Thompson) and Clausius, respectively. The transition to the statistical theory is largely the work of J. Clerk Maxwell, L. Boltzman, and J. W. Gibbs.

NOTES

1. Contemporary theologians draw a sharp line between science and theology. The scholastics avoided this. Thus the Franciscan William of Occam, c. 1300, (whose nominalist ideas still exert philosophical influence), starting with the physical observation of the condensation and rarefaction of matter, concluded that extension had no real significance and then went on to explain the mystery of the Holy Eucharist (see Weisheipl 1971, 66). While the scholastic theologians asked for more science, modern theologians ask for less. Witness what the Franciscan Roger Bacon, great proponent of observation and experiment, wrote to Pope Clement IV (c. 1267): "The neglect of mathematics for thirty or forty years has greatly destroyed the entire learning of Latin Christendom. For he who does not know mathematics cannot know any of the other sciences; what is more, he cannot discover his own ignorance or find its proper remedies" (Weisheipl 1971, 55-56). It is hard to imagine a similar plea from contemporary theologians.

Contemporary theologians also tend to separate technology and industry from the aesthetic realm. The scholastics did not. They listed as arts not just music, sculpture, etc., but also farming, weaving, and other forms of medieval industry (see St. Bonaventura [c. 1250] 1940).

2. The Dictum of Einstein referred to is: "Raffiniert is der Herrgott, aber boshaft ist er nicht" (Subtle is the Lord-God, but capricious He is not). Faith in such a God, the rational God—"Spinoza's God" in Einstein's words or "Logos I" in Masani (1981, 279)—is the basis for the scientist's confidence that his mind will be able to uncover the laws governing the cosmos, and that this knowledge can be put to use in ventures not involving stratagem. Subsuming this is the more comprehensive concept of a God that also has an altruistic dimension—the Loving God, "Logos II" in Masani (1981, 282)—faith in whom is the hallmark of the strictly religious individual, e.g., Gandhi, cf. his words: "And is this power benevolent or malevolent? I see it as purely benevolent," cf. Masani (1981, 283). Such faith is the basis for confidence that human ventures, where

stratagem is involved, (e.g., waging war, or running a university) can be accomplished in a sinless way. The more the adversaries are wicked, the greater the need for such faith.

The two conceptions of God correspond in a way to the division of science into branches where stratagem is meaningless, e.g., physics, and those where it is relevant, e.g., military science, administration, game-playing (in the von Neumann-Morgenstern sense).

3. The relationship of this principle to the classical version of the second law of thermodynamics is discussed briefly in the Appendix to this paper, in which the structure of thermodynamics is briefly outlined.

4. This is clear from the equation $S_X = S_A + S_E$, which is an easy consequence of the definition of entropy.

5. Perhaps, during the very distant past, some other (now extinct) species of the genus Homo were also so afflicted, e.g., Homo Neanderthalensis.

6. The burning of food grain by the *X's* when the *Y's* are starving offers a typical example of exploitation.

7. More fully, the communication may consist of vocatives or command signals—equivalents of imperative sentences—which may be deceptive; e.g., "for shelter turn left" instead of "for shelter turn right." The communication may also be dishonest, i.e., include declarative sentences that the speaker knows are false.

8. And so the wisdom in the jest (attributed to Samuel Butler): a hen is just an egg's way of creating another egg.

9. A poignant illustration of this is afford by T. S. Eliot's *Murder in the Cathedral.* When the Fourth Tempter entices Thomas à Becket with the words: "Seek the way of martyrdom, make yourself lower on earth, to be high in heaven," Thomas cries out, "You only offer dreams to damnation." To the chorus he explains later:

> The last temptation is the greatest treason:
> To do the right deed for the wrong reason (Eliot 1935, 39-44).

10. That is, if input signals x_1, x_2 are converted into outputs y_1, y_2, then the signal $x_1 + x_2$ is not in general converted to $y_1 + y_2$. The outcome may also involve nonlinear terms such as $y_1 \, ^2y_2$.

11. Wiener worked out a theory of nonlinear entrainment of frequency in assemblies of suitably coupled resonators, but pointed out that this was too "blue-printed" to offer anything beyond suggestive guidelines as far as bio-organisms are concerned (Weiner 1958; 1962, 13).

12. Wiener has provided an interesting link between the genetic determination of insect behavior and the nature of its respiratory system (1950, 51-59).

13. The technical substitute "altruistic gene" for "altruism-inducing gene" is unfortunate. It saves only one word but invites the amusing intimidation: "Genes cannot be selfish or unselfish, any more than atoms can be jealous, elephants abstract, or biscuits teleological" (Midgley 1980, 108).

14. The complimentary principle affects the very organization of ethological investigation. This is because the "third world" countries, which harbor the wildlife sanctuaries and their research institutes, are in dire need of hard currency; hence, they are obliged to turn the sanctuaries into tourist attractions and so to reduce their ecological integrity (see Kruuk 1972, xi). Briefly, the experiments can continue only on condition that their collimations worsen.

15. I am thankful to Karl Peters for pointing out to me the quoted passages from the story of Noah's Ark and their hidden meaning from the standpoint of the Fall.

16. I am indebted to B. Ollman for pointing this out during conversations. We say that x has the *propensity* to act in the way y, if there is a good chance that, in a specified set of environments, x will act in the way y.

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