ON "HUXLEY'S EVOLUTION AND ETHICS IN SOCIOBIOLOGICAL PERSPECTIVE" BY GEORGE C. WILLIAMS

by Ralph Wendell Burhoe

Abstract. I concur with Williams that improving human ethics requires full consideration of the biogenetic facts; but I argue that the understanding of biogenetic facts, and of ethics also, can be improved by a fuller view of nature's mechanism for selecting what is fit, a view recently generated by physical scientists. For me ethics necessarily must fit the evolved genotype, but ethics does not emerge until the rise of cultural evolution, where nature selects a culturetype symbiotic with the genotype. I outline my integrated dynamics of the relation of culturetypes to genotypes and to the laws governing physical systems. The biologist's finding that a living organism is of transient significance compared with its lines of heritage and their consequences, I argue, is constructively important for ethical and theological understanding.

Keywords: altruism; human evolution; morality; natural selection; selfishness; theology.

I am delighted to be asked to comment upon this paper by George Williams because I owe so much to him as a basic mentor for my understanding of religion and ethics in the context of biology and genetics. His *Adaptation and Natural Selection* (1966) has been for me a bible since 1968. There I found his "critique of some current evolutionary thought" a significant breakthrough to sound interpretations of how genetic selection shapes values that determine behavior.

I found then that his evidence clinched for me the theory that natural selection of genes (and hence genetic heritage) cannot produce altruism except to close kin according to the general rule of inclusive fitness. In my papers since, I have cited his and other sources of this well-established theory as being essential to my own hypotheses con-

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cerning the relevance of genetics for human values. His book came out more than twenty years ago, and I have been challenged on whether this theory is still supported. I was pleased to publish in a recent paper that I had checked this and found it remains central for biological science (Burhoe 1986, 445).

Because some readers of *Zygon* may need additional information on why Williams's biology is so important for human values, I shall note something of my evolutionary view of human values and religion and how its critical point for cultural evolution was developed from his clarifications. However, I shall also note why I feel his paper here needs to be supplemented by models of selection in cosmic and cultural evolution that give still further understanding of human values—and why I shun T. H. Huxley's views of ethics.

Williams (1988, 385) notes that nearly a century after Huxley's "Evolution and Ethics" we are driven to a more extreme position in the battle against "the enemy" since we now have an even more extreme picture of "natural selection as a process for maximizing selfishness." In my response I shall show why maximizing any entity's "selfishness"—properly translated as its dedication to its proper goals—is scientifically and theologically unavoidable for any entity or system of entities that must maintain and transmit the information for a stable or viable pattern. This applies to entities all the way from particles to animals, to humans. It applies to individuals and societies. It applies to anything of enduring significance. I explain more, below.

The Cosmic or Physical Source and Selector of Life's Values

From other mentors, including Jacob Bronowski, I have drawn a view of cosmic evolution that emerged many decades after T. H. Huxley died. This view, I think, provides a more valid and encouraging picture for life in the context of cosmic evolution than earlier scientific pictures. Curiously, this encouraging view arises in part from new understandings of the second law of thermodynamics, whose earlier interpretations cast much gloom over human prospects. Bronowski's "New Concepts in the Evolution of Complexity: Stratified Stability and Unbounded Plans" (1970)[1] was one of the new interpretations through which we have come to understand that both the evolutionary rise of order and the trend to disorder are parts of the same system. The second law of thermodynamics, he writes,

> is a true theorem in combinatorial arithmetic. . . . But it tells us little about the natural world which . . . has turned out to be full of preferred configurations and hidden stabilities, even at the most basic and inanimate levels of atomic structure. . . .

> ... The preferred configurations may be unimaginably rare; nevertheless, they present another level around which the system can bunch, and there is now a countercurrent or tug-of-war within the system between this level and the average. Since the average has no inherent stability, the preferred stable configuration will capture members of the system often enough to change the distribution; and, in the end, the system will be established at this level as a new average. In this way, local systems of a fair size can climb up from one level of stability to the next, even though the configuration at the higher level is rare. When the higher level becomes the new average, the climb is repeated to the next higher level of stability and so on up the ladder of strata.
> ... It is evolution, physical and biological, that gives time its direction. ... The progression from simple to complex, the building up of stratified stability, is the necessary character of evolution from which time takes its direction. And it is not a forward direction in the sense of a thrust toward the future, a headed arrow. What evolution does is to give the arrow of time a barb which stops it from running backward; and once it has this barb, the chance play of errors will take it forward of itself (Bronowski 1970, 33-34).

From this new view the term *nature selects* is one way of saying that in random variations, which nature ordains, one of nature's preferred configurations has turned up. Such patterns may be as tiny as atoms, as large as galaxies, and as complex and multi-layered as animal organisms or human brains or societies. Among such patterns are the solar system, the earth, the cloud "streets" and atmospheric whirls around the earth, the prebiological molecules, the amino acids and the DNA, and the species or ecosystems of life from the most primitive to the most complex (Burhoe 1970). "Stability" patterns are related to "homeostasis" and "viability."

I find it both encouraging and more scientifically credible that it is not merely an indifferent chance but a standard rule of nature that selects its preferred patterns of stability and is in charge of the selecting among the variant patterns replicated by our genes. Our salvation does not require us to do battle against cosmic law or nature. It is good to know that cosmic law made us and we are on its side. Our future will advance as we find further adaptations to what it offers and requires. This new-physics view of evolution restores the ancient belief in a system of power far transcending humanity which is ultimately responsible not only for all that has been created but also for all that will next be selected. Various sciences have conjointly shown that useful or practical information about how to act for successful life in the future can be accumulated not only by random trials of genetic patterns but also by varied trials of culturally informed patterns encoded in brains. These patterns range from preconscious to rationally written, and include the theories of the modern sciences.

To be relevant for the human predicament, we need to be more clear about what is in charge of selecting the patterns being replicated not

only by genotypes but also by the sociocultural system. How is that sociocultural system tied to the genes and the environment? Several seminal ideas have been proposed by a number of scientists, including those cited in the next section.

On Sociocultural Evolution

Richard Dawkins in his *The Selfish Gene* (1976) not only affirmed the view expressed by Williams (1966) on the selection of the gene, but he advanced human evolution by developing a theory of cultural transmission of information, with the *meme* properly added to the gene as a unit of information selected. Incidentally, Dawkins wondered whether there might not be something in cultural evolution (encoded in memes) that might counter the pessimistic picture of the selfish gene and perhaps provide an explanation of the cooperation of altruism found in human non-kin societies, which seemed to be impossible under genetic selection. However, in integrity to his own excellent draft of a theory of the selection of memes, he had to conclude that a theory of how cultural memes operated also was doomed to paint a picture of inescapable selfishness (Dawkins 1976, 211-14). Important for me is that Dawkins joins those of us who find that the selector of the memes is the same nature or system of reality that selects genes, and under analogous rules. Dawkins's work greatly helped me in my long-time search for a more satisfactory theory of cultural selection (Burhoe & Hoagland 1962), which has been greatly aided by the implications for life of recent physical theories as well as by such biological mentors as Alfred E. Emerson and E. O. Wilson (1975), as well as Williams and many others.

Emerson's "Dynamic Homeostasis" (1954) and various technical papers on termites had made clear to me the fact that creatures from two different species, not genetically related at all, can *cooperate* with one another when bound in symbiotic mutualism. This is puzzling in the context of the fact that creatures even of the same species can hardly be selected genetically to cooperate further than with close kin. Williams provided a clear analysis of this genetic paradox and its explanation. He noted that among the

> mutually beneficial relations between species [is] the mutualism between termites and their intestinal biotas. . . . These phenomena have been interpreted as indicating that a species-complex is a unit of selection and adaptive evolution. This is certainly true in a sense. Neither a termite nor its intestinal symbionts can become extinct without the other sharing its fate. Likewise the evolution of each would have been very different had the other not been there. The important question, however, is whether the selection of alternative alleles can simply and adequately explain the origin and maintenance of such relationships. I believe that such an explanation is possible and plausible in

every instance. We can expect cooperative mutualistic mechanisms to arise between any two species in which each constitutes, for the other, an important source of some aid to survival (Williams 1966, 246-47).

If what I have called the *culturetype* (which represents a constellation of Dawkins's *memes* in the way that genotype represents a constellation of *genes*) were realistically a symbiont in human phenotypes, then my task of explaining cultural evolution and human altruism would have a solution. I already had the model of *idenes* or *memes*^{2} as basic units of selection for a viable sociocultural system. I knew that each brain of a culture's genetically diverse population would have to carry some common neural information if humans were to intercommunicate in a language or be influenced by a common culture. Therefore, on the average, each brain would have to carry most of the essential information (including motivation) to operate the sociocultural system. Each brain is analogous to one of the cells with a common culturetype that collectively constitute the huge sociocultural organisms or phenotypes. The genotype of each brain, of course, is one of the variants in the gene pool. Williams had made it clear that such neural patterns leading to trans-genetic kin groups could not be programmed by the genes. Could there be a "species" that could be symbiotic with the genes of *Homo* and co-evolve symbiotically to produce humanity? It seemed to me that the sociocultural organisms might well be a mutualistically beneficial "species" (encoded in its neurally transmitted culturetype), symbiotic with the population of a *Homo* gene pool. However, culturetypes were encoded in neural—not DNA—patterns of information. That put them beyond pale of generally admissible biological concepts of symbiosis in the 1970s.

I worked on these problems in a number of papers from about 1970 to the present (including Burhoe 1975; 1976; 1979; 1984; 1986). My development of the explanation of human nature as a genotype-culturetype symbiosis was stimulated by contemplating the uniqueness of humanity, the radically high rate of its evolution, and the fact of widespread altruistic behavior to non-kin (impossible in selection of genes). I saw the possibility of a more constructive explanation of these and other empirically observable facts by the hypothesis of a true symbiosis between culturetypes and populations of *Homo* genotypes. I also contemplated the waves of emergence of molecular structural patterns from times before the emergence of the "symbiosis" of amino acids with DNA. Cosmic, biotic, or genetic evolution from time to time breaks into radically novel forms. Transmission from brain to brain of post-genetic or cultural heritages of evolving rituals, languages, religions, technologies, and other human characteristics in the post-natal brains of ape-men provides an *organic* assemblage of information

above the level of genetically transmitted information, although interactive with it in the brain. A very close coadaptation of culturetype and gene pool resulted from the fact that memes are wholly dependent upon endosymbiosis[3] of such cultural patterns in a population of "ape-man" brains, whose basal value information is genetically programmed and whose final value information is established by the interactions of the basal information with a special endosymbiotic environment—the culture—and their "species-complex" interaction with their habitat. This view implies that the genetic program of each brain is not usually violated by cultural heritages, where the culture is a mutual symbiont that can in general only modify the later expressions of a genetic program, as can any environment in a long epigenetic program of an organism's ontogeny or development.

We know something about the organization of the human brain into parts that interact as one brain (even though the phylogenetic emergences of these parts were separated by many millions of years), such as Paul MacLean's tripartate human brain with the reptilian, mammalian, and neocortical formations (MacLean 1973; 1982). If the new culturetypically programmed endosymbiont, transmitted to each human neocortex from others in the society, is replicated throughout a genetically mixed population, one can explain trans-kin altruism and human society. If this culturetype with its derivative sociocultural system were to survive at all, it must have done so by adapting to enhance benefits to the average genotypes upon which it depends, in such ways as mutual symbionts always must. From the start, these new sociocultural "brain viruses" or memes could only exist if the genotypes, on which they were completely dependent, was aided by this cultural "virus" to be more viable than a similar but competing pool of genotypes that was not so "infected." Some particular culturetypes, in symbiosis with an average sample of a *Homo* gene pool, would benefit in competition with less viable "species" of culturetypes.

To account for facts in human evolution, there must have been an equal and reciprocal selection pressure for the genes, within the sociocultural systems' *Homo* populations. This pressure would enhance the frequency of those genes that reciprocally enhanced the endosymbiotic sociocultural operations, thus jointly making a more viable symbiosis. That is, those genotypes would more often be selected which produced a more effective brain for receiving and processing cultural information to operate a more viable human society.

Because the advance of adaptive, brain-learned and brain-transmitted information may be thousands of times faster than adaptive "gene-pool learning" (genetic selection), this provided the opportunity for a radically rapid co-evolution between the two symbiotic "crea-

tures" as they operated under the resulting conditions of great positive feedback. The rate of change per generation of the *Homo* gene pool itself would be greatly accelerated. The genetic disappearance of other species of *Homo* than *sapiens* and the rapid genetic enlargement of the brain's neocortex fit the above pictures. That is a brief sketch of some elements of my model of the symbiotic co-evolution of human genotypes and culturetypes in their natural history.

Altruism, Selfishness, Evil, Freedom, and Salvation

From the emergence of this symbiotic view of human nature comes the possibility for better explanations of many questions about human nature. I suggest a few of these.

Altruism, other than to close kin, seems to be quite selectable under the supposition of some such symbiosis of culturetypes and genotypes as joint programmers of the brains of a human population. The whole sociocultural organism thus became the *unit of selection* for what amounts to a *species complex*, composed of a human culturetype inscribed in and binding together a population of brains of a non-kin population. The selection pressure on these populations rapidly yielded more viable human sociocultural phenotypes and slowly yielded gene-pool samples better-adapted to human social living. The human-individual phenotype began to include in each brain of a sociocultural population the two highly coadapted and mutually beneficial information programs: first, the expression of one genotype, a sample from the *Homo* gene pool, and, second, a local expression of a sample of the commonly shared culturetype, sufficient to provide the motivation and information that would avoid being lethal for itself or for the culture. This highly coadapted symbiosis generated a *cultural*-kin group, which shared common survival values, just as do various genetic close-kin populations. In terms of some sacred or vital cultural values that generate very high levels of reciprocal altruism, one can readily see the possibility of an index of cultural relatedness getting close to the level of "1" (100% or complete) of genetic relatedness, such as that of the cells of an organism. However, the cultural relatedness would not be effective unless it was a viable pattern of memes relative to both the habitat and the symbiotic genotype. To be coadapted with the gene pool of its population, the culturetype had to so order values in each brain that individuals who thus had become *cultural kin* would, on the average, pay off the genetic costs of the altruists—who put themselves at risk for the sociocultural organism—by socially arranged provisions for genetic inclusive fitness. The public honor and material benefits to the genetic kin of soldiers is an observable product.

These kinds of theoretical necessity and empirical evidence led me to postulate the necessity of an adequate system of culturally transmitted religious mores and values (at first more implicit than explicit, and seldom consciously or rationally planned in primitive brains or minds) as the foundation for humanity to rise above the level of the close-kin groups of the small, "ape-man" societies. Religions from primitive times have necessarily been involved in statistically effective cultural procreation of attitudes and behaviors that meet the very necessary "selfish" requirements of genes for their future as well as for viable social behavior. My hypothesis—somewhat parallel to Donald Campbell's (1976)—holds that selection of memes, which fit the viability requirements imposed by natural circumstances, has been the source of the evolution of successive levels of the ordering of human values via the religious sectors of culture. My view, using the model of memes and culturetypes as well as B. F. Skinner's operant reinforcement scheme, holds that more or less random psychological conditioning experiences—starting within extended family groups from primitive, pre-linguistic, animal-ritual stages on through the highest consciously recognized sociocultural value systems—led to a "natural selection" of public memory, especially for the more essential (sacred) levels. This had to be combined with the genetically programmed motivation, and with the capacity for retelling the message to all in the population, so that a sufficiently large fration of the non-kin population would cooperate and fight to save the sociocultural organism and its individual *Homo* organisms as a closely coadapted mutual symbiotic union. Because such symbioses could utilize the available energy in an environment more effectively than all merely genetic contenders, we see the rise of the remarkable phenomenon of humanity, still constantly being pressured to adapt relative to ever new problems, both internal in societies and individuals, and external in the environment.

Selfishness of both genes and memes in my analysis turns out not to be evil but to be both necessary and good. Faithful self-maintenance and propagation of the very expensive and essential information in genes and memes is one of the necessary providences and economies that nature has selected for living systems. This idea came to me in 1958 when reading the physicist Erwin Schroedinger's ([1944] 1956) famous *What Is Life?* In his discussion of the possibility that genetic memory might be held in an aperiodic-crystal molecule, he characterized the physical parameters of suitable stability and mutation rates. I was deeply impressed with the necessity for a sufficiently long maintenance of the same pattern of information. It became clear that self-maintenance or what some have called "selfishness" is a physically built-in necessity for genes (also idenes), and that is what makes them, in the larger view, good.

Of course, the word *selfishness* is also used to convey an evil and socially destructive pattern of behavior. This is the evil that results from a brain's tragic failure to have a suitable coadaptation of culturetype and genotype so as to direct behavior sufficient for the coadaptedness or viability of both symbionts. Common sources of evil are culturetypes that fail ro provide sufficient faith, desire, and know-how for an altruism adequate for flourishing human societies. In the failure of that information, people are prone to accept the altruistic gifts of others and, instead of providing the necessary reciprocation, act—destructively for themselves and their non-kin society—on the never-failing genetically programmed instincts characteristic of kin-group societies.

Evil, as a psychosocial phenomenon, would seem to be a characteristic of the symbiosis of a human gene pool and a culturetype. The dual natures of humans are often out of phase and incompletely coadapted to each other. Hence there may be a tension between the genotypic and the culturetypic programs that tortures the brain. The brain is designed to minimize its internal, self-defeating conflicts of interests. However, when the existing culturetypes and genotypes are not sufficiently well-coadapted, individual brains become overwhelmed and sometimes crippled. The myth of the fruit of the tree of knowledge in the garden of Eden showed early concern to account for the trouble that arises from eating that fruit. Cosmic selection (the replication of the more stable or viable structures at all levels, including molecular, genetic, or culturetypical) seems to have favored the replication of preferred stable states that overcome aesthetic, axiological, and conceptual dissonance. This selection of, say, a cultural heritage that reduced the job of individual brains to manageable size enhanced the viability of brains as the seats for coadapted mutual symbioses between culturetypes and gene pools. Animals in their natural habitats usually have not been faced with the conflicts between genotypic necessities and cultural "viruses," since animals have far less cultural information that could threaten genetic viability. Human salvation requires culturally transmitted grounds of conviction about values that not only are believed but also are valid in fact. When religion, as the name for what transmits basic cultural values, provides insufficient values to meet the actual conditions, its population tends to fall on evil times. It is clear from evolutionary theory as well as history that, in such circumstances, unless such a religion is reformed it becomes selected-out and societies, without viable and integrating values, break up into rival groups that tend to reduce in size, regressing toward the kin-group levels of ethics and organization, according to circumstances (Heilbroner 1974).

Freedom is the partial autonomy structured into brains. At primitive levels it provides freedom from possible environmental deprivations,

as do phototropic or other self-initiated actions for homeostasis or life-maintenance. With human brains and genetic and cultural inheritance, there is provided a wide network of automatic (and later rational and scientific) forebrain tests as to which of a number of possible actions will most likely yield greater success in life. This freedom or capacity to pick more quickly a more probably successful response under complex circumstances is programmed into brains by the symbiotic genetic and cultural heritages operating in the brain. With this inbuilt heritage humans have the capacity to "make up their minds" on how they will react to most circumstances. While the actual validity of a choice is ultimately selected by what the ecosystem will require for a viable response, human choices are always the first and often-successful steps in their basic life program to search to fit (or be selected by or adapted to) the larger reality of which humans are a part. Freedom of brains, relative to one another and relative to various possible choices in this search, is an example of nature's insistence on the variability necessary to find or reach a potentially higher-level on nature's ladder of its preferred stable states. Sometimes such freedom is paid for by a high cost, and too much freedom leads to evil or death. Where then is salvation from the evils that befall individuals or societies whose freedoms or whose heritages fail to provide successful life?

Salvation is an ancient religious and theological concern. In every human society salvation programs include deliverance from the social evils and also deliverance from the individual helplessness and hopelessness that result when either symbols of human evils or environmental evils invade our brains with threats to the health or life of the bodily self—the phenotype. Up to a certain age, all genetic and most cultural programs seem to have designed us to defy and overcome such evils. (Here it should be noted that the individual bodies in such groups as cells of an organism, or soldiers in an insect or human society, become, by genetic selection, evolutionarily significant, even with a *shorter* duration of their phenotype.)

For salvation now, an important step for a modern, scientifically informed theology's solution for transcending evil with good is the biologist's discovery that our present organisms are not the final goal or ultimate project of our longer-range substance. Organisms are transient compared with any of the immortal continuation of adaptedness of many species to relatively stable environments. However, organisms are even more transient compared to those species, such as ours, whose new adaptations in succeeding generations carry them to ever higher levels of complexity, and thus provide them with the capacity to live under more variable environments through their more rapidly evolving heritages that provide adaptation to the higher levels of complex-

ity. From the beginning of life, phenotypes were built to be transient and to replicate, with or without mutation or recombination, and to test, usually in relatively small steps, for adaptedness to their habitat. In an age of science, theologians can provide a credible immortality or lasting significance by viewing our *souls* through the evolving patterns of our genes in the gene pool and the consequent phenotypical expressions. If evil is felt when the new complexities of the human brain fail to provide awareness of salvatory action, hope, or significance of the whole self or soul of one's being, then suitable reform or reinterpretations of the most sacred religiocultural information is required for salvation. This rule has often been confirmed in history (e.g., Heilbroner 1974). In a scientifically informed theology, the genes can be seen as a part of a new view of immortal souls. My picture of the soul, however, in addition to recognizing the high significance of genes, has outlined the structures and relations of any human phenotype to the evolving heritages of the culture, the relation of the culture to the gene pool, and the happy possibilities of this symbiosis in an independent and sovereign environment or ecosystem (Burhoe 1960; 1973; 1975).

Concluding Statements

While I have been one to profit by Williams's important clarification of the nature of evolving life, I know there are many thousands of others who also have profited. Among those is Richard D. Alexander, author of *The Biology of Moral Systems* (1987). I wish briefly to note his work because of his special relevance for scientific contributions to the understanding of human values. Here he uses to the hilt the tradition-correcting lessons from modern genetics, as developed by Williams and others, to build upon them a new, revolutionary, and scientific explanation of human nature, including its culture, altruism, even religion. *Zygon* readers have already seen a glimpse of this (Alexander 1985). I suggest that Alexander (especially 1987) will become essential for those seeking to formulate a theology that can flourish in the context of genetics and the sciences in general.

Many of us recognize that current interpretations of religion in the language of earlier theological and philosophical concepts, without scientific re-interpretation, have often become obsolete and incredible to many. This incredibility has made the ever-essential religious and moral functions too weak for an age of science. However, many of us have found that a new evolutionary interpretation shows how essential a proper religious culture is for human society, and how new understandings of the human predicament can enrich rather than detract from an already evolved culture of sacred values in traditional

religions—values that are still significant for morals and viable civilizations (Burhoe 1975; 1986). Some of us have sought to express a credible theology in the light of the sciences. There are many problems and questions that a scientifically informed theology could help answer with wider appreciations and affirmations of religious and moral history in the light of the symbiosis of the wisdom of the body (*genes*) and wisdom of the culture (*memes*). We may be able to help reform and revitalize a sacred culture and its salvation for human ethics, for adequate moral motivation and behavior in an age of science. Present crises of all kinds in a rapidly exploding world culture call for a much more rapid clarification, re-formation, and revitalization of ethics and human values.

I am grateful for George Williams's important and clear interpretations of basic biological facts which have so greatly enriched our conceptual understanding of human nature. While I join Williams and his mentor, T. H. Huxley, on the urgent need for a reformation of the ethical element of our cultural heritage, I do not share their pessimism about the human future in the context of cosmic evolution. This is because my scientific hypothesis sees human nature as created by the cosmic nature whose hierarchies of preferred stable states always have been and always will be sovereign over the evolution of our genetic and cultural symbiosis on earth. I think our salvation from evil and attainment of a higher level of ethics will most rapidly come from our greater efforts to appreciate and adapt to that cosmic reality.

NOTES

1. Besides Bronowski, several other mentors have helped me in my understanding of the continuity of stable-state selection processes, starting with processes in the pre-living cosmos and continuing through those in ever more complex (higher) levels through genetic and cultural evolution. Because many mentors helped me more on the basis of lectures and conversations than merely a reading-list basis, and because they are cited in my various publications and/or published in *Zygon*, I shall only indicate here some of them by name, to suggest the wide range of persons working to provide a new paradigm for better understanding life and human nature in the context of the reality pictures of physicists: Eric Chaisson (1988), Sidney Fox, Harold J. Hamilton, Hudson Hoagland, Aharon Katchalsky-Katzir, R. Bruce Lindsay, Howard T. Odom, Ilya Prigogine, Erwin Schroedinger, Harlow Shapley, Herbert A. Simon, Anthony F. C. Wallace, Jeffrey S. Wicken (1987; 1988), and Norbert Wiener. Bruce H. Weber et al. (1988) have assembled and edited a good, up-to-date review (by twenty authors) of some of this new thrust to integrate biological evolution with physics.

2. *Idene* was a term coined by Henry Alexander Murray, in the 1960 conferences on evolution and man's progress of the American Academy of Arts and Sciences, to name the cultural equivalent of the gene (Burhoe & Hoagland 1962). *Meme* was coined by Richard Dawkins (1976).

3. Endosymbionts are populations of symbionts (for instance, bacteria) inside another organism, such as the intestinal symbionts mentioned in the fourth sentence in the above quotation from Williams. I view culturetypes and hence cultures as primarily the neural patterns transmitted by sociocultural organisms to the many brains in its

population. Human artifacts, including libraries, are extrasomatic refletions of what goes on in brains and have become very important for transmission of memes.

4. I am much indebted to Donald T. Campbell who about 1968-69 introduced me to Williams (1966) and rubbed my nose in its implications for our understanding human nature and for understanding cultural and religious evolution.

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