Genes, Genesis, and God in Natural and Human History

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Genes, Genesis and God in Natural History

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Here we present Holmes Rolston's Research Conference proposal, wherein he states the direction of his present research, which relates aspects of genetics to ethics and philosophical theology. He asserts an axiological paradigm for interpreting biological data, hoping that it will provide richer theological possibilities than we have been given by sociobiologists.

Biology and theology can be troublesome to join. Biological nature, we may be told, is blind and random, full of selfish genes, and this can seem ungodly. By contrast, physics and theology today are much more congenial; astronomical and microphysical nature, we may be told, is fine-tuned for life, the anthropic principle. Perhaps we can take a lesson from history; those who tried to join physics and theology a century ago had much difficulty. Partly this was because theology needed reforming, but even more it was because the physics wasn't ready. The paradigms of space, time, matter, energy, determinism, objectivity, and so on, had to change, as has happened over the course of the twentieth century.

Facing the twenty-first century now, the trouble is that theology needs reforming, but even more the biology isn't ready. The paradigms need to change; and to that end, I am going to maintain, the trouble lies in misapplied categories of selfish, blind, random, valueless nature. The revolutionary categories that I propose will be those of values achieved, actualized, shared, and conserved in a natural history of dramatic creativity. Such a reinterpreted biology will be much more congenial to theology. Where there is creativity, there may lurk a Creator.

I.
SELFISH GENES AND SHARED VALUES

A. Selfish Genes?

In his now classic *Sociobiology,* Edward O. Wilson tells us, on the first page, about "the morality of the gene" (Wilson 1975, p. 3). In *The Selfish Gene,* Richard Dawkins opens by telling us, "We are survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes" (Dawkins, 1976, p. ix). George C. Williams concludes, "Evolution is guided by a force that maximizes genetic selfishness." "The evolutionary process is immensely powerful,... it can reliably maximize current selfishness at the level of the gene" (Williams, 1988, p. 391, p. 400). L. E. Orgel and F. H. C. Crick report the discovery of "Selfish DNA: The Ultimate Parasite" (1980).

We would be amused if these references were to the morality of the liver or the morality of the endoplasmic reticulum, for organs and organelles cannot be moral agents. But genes do code for life (for livers, cells, and also organismic behaviors as a whole) and perhaps there can be a morality of genes. Genes govern the process; they are not simply products, and maybe there is some selfishness in the executive program.

It is logically essential to the ordinary concept of selfishness that some entity (a "self") act or behave in its own interests in an arena where pere entities (other "selves") have interests that can be acted for or against. We must be able to identify one self among other selves where the resultant of behavior benefits one and costs others. In the case of a selfish gene, the contrasting class would be other genes located within or without a particular individual organism. Gene A benefits; gene B loses. There are sometimes nonrival benefits. Gene C benefits; gene D benefits; no gene loses. Both beneficiaries may be acting, each in its own interests, but unless one can behave in its interests and against the interests of others, the possibility of selfish behavior lapses.

If, in the affairs of moral agents, we had some access to motives and knew that C intended loss to D, though C was mistaken about the result, D gaining instead, we might call the intentions selfish, but of course genes have no intentions to consider. Those who speak of selfish genes do not think that genes are "conscious" (and acting selfishly unawares is often met in morals), so it is behavior to which they refer. But we arc going to need an analysis of this behavior (if indeed genes can "behave") in order to know what this form of speech means.

It is essential, for instance, to any selfishness which we censure that the agent acting selfishly has an option otherwise. Ought implies can; ought not implies can do otherwise. Since it is not clear that genes have any such options in their behavior, we may not be dealing with censurable selfishness. We might be dealing rather with a compulsive selfishness, governed by the genes as they determine (but do not choose) behaviors. Already we see that we need to be circumspect about selfishness in genes.

One of the first questions to arise is whether one gene can act against the interests of other genes that cohabit the same organism. No gene stands alone; every gene is located in a fishnet of fishnets of levels—biological molecules, organelles, cells, organs, an organism, an ecosystem—and it is difficult to think what it would mean for a single gene to operate "selfishly" in any biological sense (even before we ask whether such an idea makes moral sense). Part of the problem is that the benefits and costs accrue at a level different from that at which the gene immediately acts. Earthen biology operates through individual organisms (phenotypes), bounded by skin or bark, evident at our native ranges; and there is also evidently something transmitted genetically (in seeds, spores, sperm, eggs), hereditary material that biologists can examine microscopically and locate in genes (the genotype). Connections between the genotype and the phenotype are fraught with complexity.
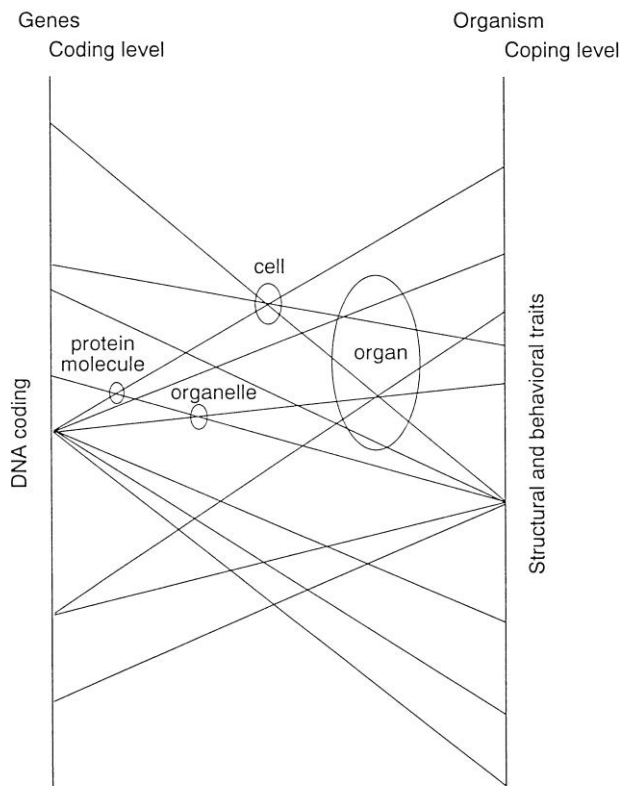

Figure 1.
Genes in Organisms

Consider a diagrammatic sketch (Fig. 1) showing a genetic level of *coding* and an organismic level of *coping*. At the level of *coding* life is reproduced through time, overleaping death, though the diagram is not yet historical. The secret of life is inherited from life to life. At the level of *coping* the living organism, having inherited life, is webbed into its environment, though we do not show diagrammatically this outside world either. Regeneration takes place with duplication of DNA at the microscopic coding level (resulting in regeneration at the organismic level); natural selection takes place (at least directly) at the macroscopic coping level. Both levels are required for survival, living on and on through time. In between are megamolecular levels (a protein molecule, an enzyme), cellular levels (an ethrocyte, a neuron, organelles such as ribosomes or lysosomes), and organic levels (heart, pancreas).

Every organism lives in dynamic process; all the somatic material must be not only initially assembled but thereafter vitally maintained. Structure and metabolism both are genetically controlled, with the genotypic level doubly crosswired to the phenotypic level. One gene may affect numerous phenotypic traits (pleiotropy); a single morphological or behavioral trait may depend on the contribution of many genes (polygeny).

We can doubt whether it is appropriate to speak of the fitness of a gene, since the concept of fitness may only apply at the coping, not the coding level Meanwhile, if there is any such thing as the fitness of a gene, for most genes this is an incremental contribution wired into a mesh. A pleiotropic gene might increase fitness at phenotypic characteristic$_1$ (the main locus of its expression), but it may also increase fitness a smaller amount at phenotypic characteristic$_2$ (serendipity at another locus) and even decrease fitness slightly at phenotypic characteristic$_3$ (a benefit typically has its cost). Most if not all genes are pleiotropic (have multiple effects) and epistatic (affect one another's effects).

Seldom can we think of any one gene as producing one phenotypic product that confronts the environment independently. Perhaps there is a single gene that produces the melanin that colors moths darker for better camouflage in a smoke-filled countryside. Such a gene might be selected for rather directly. Or there might be one gene selected because it by itself produces an enzyme that makes an animal more aggressive in defending its territory (though most enzymes are polygenic and most behavioral traits polyenzymatic). But few genes will operate so simply and directly.

B. Selfish Organisms?

Turning from skin-in to skin-out biology, we may first think that although the biological individual is quite organismically coordinated, with its many genes and their products integrated into one organism within the skin, nevertheless, facing outward, life is lived as a singular

biological individual. The organism is on its own in its Earth habitat. Within its environment the organism has some capacity of individual fitness, packaged up with boundaries at the edges of the particular living individual. This quantity of fitness must compete with other organisms who likewise themselves individually have more or less fitness. At this point we do have natural selection operating to select the best adapted fits, those coded for the best coping.

The paradigms need to change ... the trouble lies in misapplied categories of selfish, blind, random, valueless nature. The revolutionary categories that I propose will be those of values achieved, actualized, shared, and conserved in a natural history of dramatic creativity.

Now "selfish" behavior becomes more plausible. Behavior is a characteristic of the organism, not of this or that gene. Again we must ask, as logically essential to the concept of "selfish," whether there is an identifiable entity (a "self") that can act or behave in its own interests in an arena where peer entities (other "selves") have interests that can be acted for or against. We must be able, once again, to identify one self among other selves where a resultant of behavior benefits one and costs others. In the case of a selfish organism, the contrasting class will be other organisms, either of the same or other species.

Still wondering whether there is any moral component here, we can at least begin to make sense of biological selfishness. An individual organism, encased by skin or bark, is little trouble to identify. The network of its coordinated parts comes to integrated unity in the organism as a whole. That is the "self." Moreover, such organisms can and frequently do behave so as to benefit themselves at cost to others. One chicken grabs a grain of corn in the barnyard, and others do not get it. A chicken eats a worm; the chicken benefits; the worm loses. So it certainly seems that an organismic self can act against the interests of other organismic selves.

Organisms include plants and well as animals, and we do not usually think of plants as "behaving" this way or that; they do not "act" in the ways that animals act because they cannot move around and do things. Nevertheless some things that plants do as a result of their genetic programming benefits one plant at cost to other plants with which it competes—for water, sunlight, nutrients, and so forth. Neither plants nor animals have intentions about this in the reflective sense that is required of moral agents. Except possibly for some higher animals, it is not possible for them to do otherwise. So it is still not clear that selfishness is an appropriate category to apply to genetically-based behaviors and performances, where there are no options. But at least we can see how one organism can gain while other organisms lose, and so perhaps we have a precursor of selfishness, or a biological analogue to selfishness.

In the higher organisms that "behave" and "act" we find however that they often cooperate with one another. They mate in pairs and rear their offspring, they hunt in packs, they nest in colonies, they give alarm calls, they lead each other to food sources and share them. How are we to explain this behavior?

C. Selfish Genes and their Kin

No animal lives alone; each is a member of a family—parents, siblings, cousins, offspring. To take the perspective of an alleged "selfish" animal, when we ask about "my genes" we have to enlarge the scope of that "my." The prevailing account of behavior toward family members goes up to the family level at the same time that it goes back down to the genetic level. If we try to take the gene's eye view again (as we must do when the main interests at stake are copying, reproducing in families), we have to think of a gene as being present not only in a single cell but in all cells where there are copies of it. Since a gene is a kind of information, this is somewhat like asking where is the book, *War and Peace*. It is wherever there is a copy. So a particular gene is co-present in myriads of cells within any one individual. That particular gene may be likewise co-present in relatives, copies within kin in a different skin.

Facing out, we find that we are sometimes facing in, finding ourselves in others. Expanding the concept of the self, the survival and reproduction of a relative is partly equivalent in evolutionary effect to one's own survival and reproduction. This involves an "inclusive fitness" (Hamilton 1964). Inclusive fitness adds to individual fitness a shared fitness. To narcissistic biology we must add nepotistic biology. "We are evidently evolved not only to aid the genetic materials in our own bodies, by creating and assisting descendants, but also to assist, by nepotism, copies of our genes that reside in collateral (nondescendant) relatives" (Alexander, 1987, p. 3). Assistance to a relative will be favored if the benefit to the relative, proportioned to the degree of relationship, exceeds the cost to the donor.

That clouds the seeming clarity of having located a "self" that can be selfish. It is not just the organismic (somatic) self that counts; it is the reproductive (genetic) self, so to speak. Organisms cannot reproduce their exact selves at all; an offspring, even a clone, is a different self, inside different skin or bark. That is the first loosening up of the concept of self. Next, genetically speaking, the "self" is more or less present in all the conspecifics. In relatives, a self's act preserves a self s genes even if the self is not the one to perpetuate them. In most sexually reproducing organisms an individual shares one half of the genes of his or her siblings and one eighth of the genes of his or her first

cousins. If faced with a choice of benefiting oneself versus benefiting more than two siblings or more than eight first cousins at cost to oneself, the "selfish" thing to do is to benefit the relatives. That costs the somatic self of the acting organismic individual, but it benefits the reproductive self of the genes. Individuals and their selves do not really divide up like this, of course. We cannot meaningfully speak of 1/2 of a self, 1/8 of a self, as though a whole self here at cost could benefit 1/8 of itself there, 1/8 of itself yonder, 1/8 of itself elsewhere. But we can compute like this if we revert back to the genetic level.

Continuing (per impossile) to "think like an animal," trying to think "selfishly" "my genes" means "my gametes," transmitted during meiosis. "My gametes" would have to mean, looking to the past, before my conception, gametes that I inherited from parents, from my grandparents, back further than we can trace in an exponential widening of ancestral family into community. I do not originate "my genes" at all; I inherit them more or less, because "my" set is unique as a kaleidoscopic recombination of a gene pool, perhaps with a few novel mutations. I have "my" set of genes, but I have this set temporarily across my lifetime, receiving copies (in shuffled, mutated set) from predecessors, and passing copies on (in shuffled, mutated set) to descendants.

"My gametes" means, looking forward, that as I conceive, I will pass on a variant set. These gametes, shuffled earlier at my conception and shuffled again now when I am conceiving, are mine in the sense that I am a transient carrier of a historical line. "These are my genes," means "This is the genetic line that I instantiate." Or, better, since I have only some of the alleles that are also being passed down the line, it means, "This is the genetic network that I sample as an example, drawn from the populational pool." That sample, drawn from the past and bequeathed to the future, is all I have to be "selfish" about, but "selfish" is beginning to look like an odd word in this context

If we think of this inclusive fitness as a kind of wave front moving through time (fig. 2), the individual fitness is shared with kin on all sides, more and less with mother, father, sisters, brothers, children, cousins, uncles, aunts, nieces, nephews, all those "blood relations" in whom there are partial copies of "my genes," of whose genes "my genes" are partial copies. "Inclusive" is hardly a bad word; it really mellows "fitness" (not a bad word either) from the skin outward, just as the hierarchical networks within the skin mellowed any hard talk of selfish genes. From the "point of view of a gene" (if there is one), it does not matter whether the descendants (gene copies) are mine immediately, as a result of my individual fitness, or in my family (inclusive fitness, within two brothers, or eight cousins, and so forth). If I fail entirely to reproduce copies of any of my own individual genes, it is just as well to have copies transmitted over there in my cousins. Narcissism and nepotism are all the same.
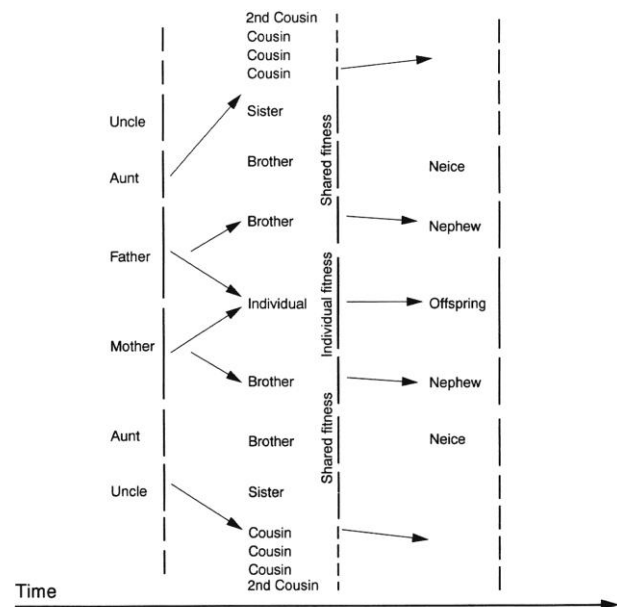

Figure 2.
Inclusive fitness through time

The fitness referred to now is smeared out across the whole family; some is within me, some in brothers, cousins, parents, children. It does not seem so "selfish" to push that sort of fitness. If one insists on the word, the individual acts "selfishly" in his or her own interests, but "selfish" has now been stretched to cover benefits to father, mother, niece, nephew, cousin, children, aunts, uncles, and so on, however far one chooses to look along the indefinitely extended lines of relationship, lines that fan out eventually to all my conspecifics. The "my" that once was located from the skin in has been so reallocated that it is now an "our." In this more complete picture of what is going on, "inclusive fitness" may be a viable concept, but "inclusive selfishness" is beginning to sound puzzling, maybe a kind of contradiction in terms. There is nothing ungodly or immoral, of course, about sharing within the family, local or extended. "Charity begins at home."

We hardly know whether to say that some helping behavior, directed at a relative, who partially contains a copy of my "self (and is in turn helping me) is a "self-sacrificing" or a "self-interested" act. It depends on where we post the boundaries of "self." If self spills over and fragments to benefit many family members, one can still call it selfishness, if one must. But this behavior can, with as much plausibility and more, be called the organism's pursuit and sharing of its own *proper* life (L: *proprium,* one's own), which is all that the (nonhuman) individual organism either

can or ought to pursue, a life embedded in its population and community. The organism has no other competence, much less any other duty. What is so selfish, so pseudo-altruistic about participating in spreading something shared? The organism has nothing else it can properly do, and what it is doing is defending and sharing its life, a process that we can vitally respect

C. Selfishness Projected onto Nature

The "selfishness" alleged of these genes typifies many words loaded with moralistic and pejorative overtones. There is "aggression" in ants, honeybees, hamsters, crustaceans, birds, carnivores, primates (Wilson, 1975, see his index). Gorillas and wrens "lie to one another" and get "cheated" (Wilson, 1975, p. 119, p. 326). Lions, guppies, salamander larvae, even termites are "cannibals"; not just langurs but even wasps practice "infanticide" (Wilson, 1975, pp. 84-85, p. 246). "Hyenas are truly murderous" (Wilson, 1975, p. 246). There is "warfare" and "slavery" among ants (Wilson, 1975, p. 50, pp. 244-245, pp. 368-371). A mallard duck commits "rape" (Barash, 1977,1979, p. 54, defending the term when challenged). There is "adultery" in the mountain bluebird and "prostitution" in tropical hummingbirds (Barash, 1979, p. 78; 1977, pp. 159-60). "Females of *Eulampis jugularis* [a tropical hummingbird] use mating behavior [sex!] during the nonbreeding season to gain access to rich food sources being defended by males" (Wolff, 1975, p. 143). A wren is caught in "cuckoldry" (Wilson, 1975, p. 327). "Promiscuous" male primates are "fickle" and "desert" females after breeding, though other males "guard" their mates (Maynard Smith, 1982, p. 27). Animals can be "jealous." "Spite" may exist in caterpillars (Wilson, 1975, 118-19). Even a tree whose roots absorb phosphates and whose leaves are elevated into the sunlight, shading understory shrubs, gains "at the expense of its neighbors" (Wilson, 1975, p. 85). Plant selfishness is unsurprising, of course, if deep down there is genetic selfishness.

Shades of the big bad wolf! They are all morally rotten. If we take this model literally, the natural world is squalid through and through. When a farmer goes out to the barnyard to feed the chickens, throwing out some grain, the chickens run and peck it up as fast as they can. By this account, the farmer should watch which greedy chicken grabs the most corn, and eat that one next, to remove the most iniquity from the barnyard!

But we are now realizing that the seemingly pejorative picture we are getting is theory-laden because the "selfishness" and the "aggression" is in the eye of the beholder. We are viewing wild nature through a human prism; and, though this is said to be objective hard science, it really is just a subjective way of framing the problem, and other frames are equally as plausible, indeed more so. Sometimes it seems as though sour morals is being disguised

as hard science, perhaps unconsciously. Sometimes this seems almost a return to animism—talk of "selfish genes," "adulterous bluebirds," and "spiteful caterpillars"—even though elsewhere such talk will be checked by an occasional caution that we can strip off the metaphor, strip off the "anima" (spirit) and retranslate the whole behavioral pattern as cause and effect. But if this is so, all these moralistic overtones package up the theory in a pejorative terminology, a rhetoric, and the theory is not revealing anything about values in nature; it is just confusing us.

Many sociobiologists tend still to approach biology from a perspective where the fittest who survive means those red in tooth and claw. "I think 'nature red in tooth and claw' sums up our modern understanding of natural selection admirably" (Dawkins, 1976, p. 3). "The process and products of evolution are morally unacceptable . . . and justify an. . . extreme condemnation of nature." "I account for morality as an accidental capability produced, in its boundless stupidity, by a biological process that is normally opposed to the expression of such a capability" (Williams, 1989, p. 383, p. 438).

What is selfish about sharing vital information, or, to use a category toward which we are headed, about sharing a value? The fauna and flora do not so much love propagating themselves, as propagating their know-how. This is not narcissistic biology, not nepotistic biology; it is epistemic biology.

For several decades, however, biology has emphasized survival of those with better adapted fit, meaning those who fit into their ecological communities. An alternative, equally biological theory can interpret these same facts as adjusted fit into a community. Indeed a less pejorative theory will be a better one, because sociobiologists are reading back objectional features from culture into nature, speaking as though animals and genes were ethical agents in conditions of only superficial similarity. Theories are like suits of clothes; they do have to fit the data more or less, but a great deal depends on how you want to dress things up.

E. Self-actualizing, Value-conserving Genes

If one insists on a word with the root etymology of "self," then one can call gene expression and the resulting behavior in an organism "self-actualizing" or "self-defensive" behavior, and realize that there is nothing intrinsically bad about either. The defense of whatever life one has is the core of all vitality. Life undefended is death. "Selfish" suggests that genes can be unkind, when genes can only defend their kin and kind, and in the only sense available to

them they cannot be un-kind (against their kind). What is selfish about sharing vital information, or, to use a category toward which we are headed, about sharing a value? The fauna and flora do not so much love propagating themselves, as propagating their know-how. This is not narcissistic biology, not nepotistic biology; it is epistemic biology.

If you are born and bred to transmit information, then you must transmit the information you have, and not some other information you do not have. You will transmit that information as it contests and complements other information simultaneously transmitted by others. The DNA code makes reprints, generation after generation, but we do not complain that only the books that sell (influence others) remain in print. Biologists, philosophers, and theologians should no more object to DNA replicating itself than they do to their books remaining in print in constant re-edition. What we want in both academic and ecological systems is critical development tested against survival in which fruitfulness is a test of survival power.

Every organism must be self-projecting, pushing itself forward. But by the revised account, that is not nasty; that is the beauty of life. Self-development, self-defense is the essence of biology, the law of the wilderness. An organism is the autonomous seat of its own life program, as rocks and rivers cannot be. The coping organism is coded at its information center. A life is defended for what it is in itself, without necessary further contributory reference, although, given the structure of all ecosystems, such lives necessarily do have further reference. The organism has something it is conserving, something for which it is standing: its life. Organisms have their own standards, fit into their niche though they must. They promote their own realization, at the same time that they track an environment. They have a technique, a know-how. Every organism has a *good-of-its-kind;* it defends its own kind as a *good kind.* As soon as one knows what a giant sequoia tree is, one knows the biological identity that is sought and conserved.

Let us choose a positive axiological paradigm, rather than a negative ethical one. We can rewrite "selfishness" as "the conservation of intrinsic value." This too will be an interpretive scheme, a more plausible one we think, but if not that, it illustrates at least how the sociobiological account is itself interpretive. Bacteria, mice, chimpanzees have projects of their own, each a life form to be defended for what it is intrinsically, and to label this "selfish genes" misunderstands the biology and the metaphysics of what is going on. Every organism must project itself in the world. Instead of thinking of a ground squirrel, much less a single gene within a ground squirrel, as acting "selfishly," we will substitute the equally descriptive but nonpejorative acting "for its own sake," and even substitute the positive "to protect its intrinsic value." These are "axiological genes."

These genes, transmitted, are not so much slivers of a self, selfishly protected, as are they elements of value conserved by giving them away, a transgenerational contribution of value. Here we can see again why genes are like thoughts or sentences. But a shared thought, transmitted when a gene reproduces, is difficult to interpret selfishly. When such information overleaps death it would seem as appropriate to say that it has been "shared" (distributed) as that it has been "selfishly" reproduced (hoarded). Since a parental organism "donates" (disseminates) information to offspring via genes, "altruism" is as easy an inference as is selfishness, if one insists on moral labels. Genes are no more capable of "sharing" than of being "selfish"—it must at once be said—where "sharing" and "selfish" have their deliberated, moral meanings. Since genes are not moral agents, they cannot be selfish, and, equally, they cannot be altruistic. But they can transmit information; and, if we are going to stretch a word employed in the moral world and make it serve in this amoral realm, then "share" is as descriptive as "selfish" and without the pejorative overtones. Genes do generate; they reproduce or communicate what they possess; they share [=distribute in portions] their information literally, although preconsciously and premorally.

That places each gene where it belongs, on a commons in which it participates. What is selfish about disbursing vital information, sharing a value? There is nothing ungodly about biological conservation. Natural history is not an evil scene driven by maliciously selfish genes. It is a wonderland of adaptive fit, a community of intrinsic values woven instrumentally into a systemic web. We want a nonhumanistic, nonanthropocentric account, one unbiased by our morals. This is really a much better paradigm, because there is no good reason to think that genes are selfish; there are no moral agents in wild nature even at the organismic level, much less the genetic one. But there is good reason to think that there are objective, nonanthropocentric values in nature, and that these are defended and distributed by wild creatures in their pursuit of life.

Only humans are moral agents, but myriads of living things defend and reproduce their lives. The axiological paradigm is the objective and natural one. The ethical ("selfish") paradigm is subjective and humanistic. Curiously, sociobiology wearing its morally colored eyeglasses, though supposedly an objective science, sees the biological world falsely because prejudiced with a baggage from culture, and often from moral failures in culture (rapists, adulterers, and selfish aggressors) at that. We want to try to pass judgment on the value of nature for what it is in itself, with criteria appropriate to nature, not with anthropocentric criteria. Let nature be what it is; do not fault it morally. Value it biologically; do not disvalue it ethically.

This is value vocabulary, but the point here is that in the genetic world value vocabulary is more accurate descriptively than is moral vocabulary, for genes essentially are information, and information is of value. A gene is an information fragment, a puzzle piece in a picture of how to make a way through the world; and such a fragmentary piece

is of value to survival. That is not a selfish thing; that is a valuable thing. We are first describing what is the case when we model the phenomena so, and, after that, we may also value such value, often prescribing that such value not only is, but ought to be conserved in the world.

"Let the earth bring forth living creatures according to their kinds" (Genesis 1.24). The production and defense of natural kinds is what is involved in the seeming "selfishness" of the genes. This is not a deplorable somatic selfishness at all, but the historical evolution and reenactment of individuals instantiating the diverse natural kinds. That cannot be evil. After all, if we take a monotheistic view of the matter, God created Earth as the home (the ecosystem) that could produce all those myriads of kinds. The God who instructed Noah to save them all (the first endangered species project) has considerable interest in defending natural kinds. There is nothing ungodly about a world in which every living thing defends its intrinsic value, defends whatever values it has achieved from its own perspective. There might be something godly about a human kind that, made in the image of God, could oversee this panorama of natural history, and again find that it is "very good," rejoice in it, and conserve such created wildness.

II.
BLIND GENES AND INFORMATION SEARCHING

A. Blind Tinkering

Well, perhaps the "selfishness" was a misapplied category, perhaps what we have in biological nature is better described as intrinsic values actualized, defended, and shared, but such a process happens within particular organisms as they reproduce their kind and transmit information from one generation to the next But still there is trouble: the process of this generation is random and blind, piecemeal and clumsy. Frances Crick complains that biology is not "elegant." As organisms evolve through that interplay of chance and necessity called evolution, they become incrusted with mechanisms and tricks that might have no more overarching logic than the layout of the Manhattan subway system. An organism has a history in a way that an atom or a galaxy does not (Crick, 1988). Stephen Jay Gould insists that the panda's thumb is makeshift and that orchids are "jury-rigged" (Gould, 1980a, pp. 20-21). Francois Jacob characterizes evolutionary history as millennia of "tinkering" (Jacob, 1977).

The contrast is deliberate intelligence. For example, in science and engineering. Incremental blind trials (making a mutation at random in the cogs and wheels of a watch) fail with high probability, but deliberated trials (replacing a gear that is failing frequently with one made of stronger alloy) often succeed because they arc made with an overview of the whole and an analysis of where the problem

area is located. Blind trial and error is devoid of any gestalt that controls educated guesses about what improvements in theory or practices might work and why. Engineers make incremental, deliberated experiments controlled from the top down, holistically, by an overall pattern that is partially already in place or envisioned. By contrast, in nature an incremental genetic mutation bubbles up from below at random with regard to the whole.

But we are now realizing that the seemingly pejorative picture we are getting is theory-laden because the "selfishness" and the "aggression" is in the eye of the beholder. We are viewing wild nature through a human prism; and, though this is said to be objective hard science, it really is just a subjective way of framing the problem, and other frames are equally as plausible, indeed more so.

In natural selection, if it can't be done incrementally, it can't be done. Development can only be by piecemeal modification. The organism has to work while it is being made. The evolving organism has to be able to get there from here, step by step, with the organism alive every step of the way. Not only does the species have to live during its evolution, it has constantly to compete and win. This demand for immediate advantage can prove a long-term disadvantage. In natural selection, it is difficult to get from local optima over to much better optima some distance away, because these cannot be reached incrementally without a downhill traverse over nonoptimal paths. So we get not the fittest possible, only the fittest that could be reached incrementally and historically from where ancestors had managed to get. It is as if the only boats that could be built had to float while under construction, or as if the only airplanes that could fly had to be assembled up in the air. Even more, it is as if these boats and planes had to race while being made. By contrast, in science, one can envision a whole boat or plane, plan it, assemble all the parts, and then turn on the switch and start it up at the last minute. If it fails to perform as hoped, if it needs repairs, one can shut it down, bring it into the shop, and overhaul it completely.

But the engineering form of creativity, appropriate for artifacts and machines, may not always be the better form. Creative development with vitality is regularly incremental and alive each step of the way. A mature person can only be made out of a fertilized ovum, vital developmental step by vital developmental step. Scientists do not engineer their artifacts this way, but scientists (philosophers or theologians) can themselves only be made out of newborn infants, incrementally over decades. The way to think of

this required historical development may be not be to term it, somewhat pejoratively, piecemeal modification; rather we are dealing with development along a story line. Lives have to be narrated, not engineered. Scientists may engineer their artifacts, but the lives of scientists (and all human persons) have to be biographies. Life has its revolutions and conversions, its dramatic crises; still it has to.be lived incrementally and vitally day by day. Robots can be assembled and switched on; but persons have to be assembled while they are living. That may be the nature of all self-generation.

B. Genetic Creativity

We do not wish to dispute that there are forms of creativity available in science that are impossible genetically. On the other hand, genetic creativity is really quite startling in what it has produced: many millions of species all the way from microbes to persons, coded for coping in all kinds of environments, and we want to think further about whether this is random and blind. We need a new paradigm. Genetic vitality may be in fact a rather sophisticated problem-solving process; many achievements made there aeons ago are not yet possible for scientists to duplicate.

In reproduction the genetically originated novelties are formed in a shuffle that, while blind to the organismic needs, is far from chaotic and is only more or less random. Any and all variations are not equally probable. Genetic and enzymatic controls on the variation process limit the range of trials. There are different mutation rates at different genetic locations. Mutators and antimutators increase or trim the mutation rates as a function of population stresses (Gardner, 1975, pp. 267-303). Specific mutations are nondirected, but the rate and place at which they occur is partially regulated. There is a tendency for genes to sort in blocks, often pretested blocks (Mayr, 1963, 1976). Repair mechanisms snip out certain genetic errors, and thus eliminate some variation. The genetic program has the capacity (if we may put it so) to "reject" some of the random recombinants on the basis of information already present in the genetic coding. Individual genetic sets are adept at pumping out their own disorder. But they do not pump out all novelty; that would cease evolutionary development.and lead to extinction. There is a shake-up of the genes under environmental stress, so that the fastest evolution toward variant forms, often more highly organized forms, takes place almost explosively after major geologic crises.

Mutation is usually kept slight and conservative. Chaotic mutations that code for nothing do not even begin to produce the biomolecular units or subunits of proteins, enzymes, or lipids that were previously coded for in the unmutated gene. Other radical mutations that do produce structures, but nonfunctional ones, immediately abort. The only mutations that really get tested are those incremental enough to fit cooperatively within the whole organismic

organization, or, rarely and surprisingly, those quantum leaps that still fit cooperatively enough to allow their trial in the life of a phenotype. So there is constraint as to what random ideas are much or at all tested.

So what is so disvaluable about natural systems? ... The process is not so blind and stupid as once thought; to the contrary it is a remarkable precursor of intelligent thought, with creative achievements that our human intelligence has yet to match.

The challenge is to get as much versatility coupled with as much stability as is possible, but this is a matter of optimizing twin maxima. On the one hand there is selective advantage in using as much of past knowledge as is possible, even in keeping that which might be useful; on the other there is advantage in quickly breaking through to something new where this is possible or required. Many variations are not eliminated but made recessive, transmitted by infrequently expressed genetic potential that is kept as versatility, subsequently favored if environments alter. The dominant/recessive phenomenon in genetics is a way of storing variability that is not usually expressed in a stable environment, but which is nevertheless there when the environment shifts. There may be a large number of such recessive alleles waiting in the population. Should these shifts come, the species is ready to cope with a broader range of environmental conditions than the usually stable environment requires (Ayala, 1978).

When rabbits vary, whether through expression of variant alleles or through mutation, some are not immobile, some traveling at twice their previous velocity. Rather, some run a little faster, some a little slower, and the extra or reduced speed must integrate with benefits and costs to all the other vital rabbit activities. The variation that really emerges for natural selection to operate on is subject to prior constraint by the accomplished successes of the organism. The process is blind in that the variations are not generated by the needs of the organism, but only those variations are tested and selected that are more or less functional. Probing is restricted to the cutting edges. In biology, now similarly to ordinary science, the organism typically only searches the nearby space for possible directions of development

C. Smart Genes

Contemporary geneticists are insisting that we misperceive this process of variation in organisms if we think of it as being blind. It is not deliberated in the conscious sense; but it is cognitive, somewhat like computers, which, likewise without felt experience, can run prob-

lem-solving programs. There is a vast array of sophisticated enzymes to cut, splice, digest, rearrange, mutate, reiterate, edit, correct, translocate, invert, and truncate particular gene sequences. There is much redundancy (multiple and variant copies of a gene in multigene families) that shields the species from accidental loss of a beneficial gene, provides flexibility, both overlapping and unique detail, on which these enzymes can work.

John H. Campbell, a molecular geneticist, writes, "Cells are richly provided with special enzymes to tamper with DNA structure," enzymes that biologists are extracting and using for genetic engineering. But this "engineering" is already going on in spontaneous nature.

> Gene-processing enzymes also engineer comparable changes in genes in vivo. Cells deliberately manipulate the structures of their gene molecules for phenotypic and possibly evolutionary goals . . . We have discovered enzymes and enzyme pathways for almost every conceivable change in the structure of genes. The scope for self-engineering of multigene families seems to be limited only by the ingenuity of control systems for regulating these pathways.

These pathways may have "governors" that are "extraordinarily sophisticated."

> Self-governed genes are 'smart' machines in the current vernacular sense. Smart genes suggests smart cells and smart evolution, ... the promise of radically new genetic and evolutionary principles" (J. H. Campbell, 1983, pp. 408-410, p. 414).

Such engineering of "selves," as we just noticed, is importantly different from the engineering of artifacts, which have no vital selves; nor is it deliberate in the conscious sense, but rather in the programmed sense of a computer on problem-solving search. Such a program, however, is autonomous to the organism, not the artifact of a human programmer.

In fact, in certain kinds of problem-solving searches, so far from disparaging the blind groping of genes under natural selection presses, computer scientists may deliberately seek to imitate a similar process on their unconscious computers. Some sophisticated computer programs use what are called "genetic algorithms." An "algorithm" is a set of instructions or rules that is repeated to solve a problem. In simpler computing programs these algorithms can be precisely and logically specified. But in more complex programs, they cannot, because they are not known.

Nor can there be random searches because all possible solutions to a problem are so numerous that it would take a computer millions of years to check them all.

"Genetic" algorithms involve combining and recombining partial solutions to a problem in order to generate improved solutions. The model for such programs is biological, sexual mating and strings of genes on chromosomes that can be shuffled and selected. The underlying metaphor is natural selection. Scientists may want to program a computer to search for the optimal set of values to solve certain multi-valued problems where the values interact with each other, such as solving certain sets of mathematical equations, or detecting patterns against a background of noise, or scheduling the most effective work and meeting times for many dozens of employees in a manufacturing plant, each of whom has different time slots available, different pay scales, and each of which contributes different skills to the production process, and many of which have to operate together or sequentially. The computer will generate at random some "bit strings," or "genotypes," analogous to information coded on chromosomes, which are possible values in solution. These sequences are its initial "population." It will then test members of the population for effectiveness at a solution, rank them for what the computer scientists call their "fitness," and select the fittest.

The computer will then generate new possible solutions, stimulating variations on the highest ranking ones, inhibiting the lower ranking ones, evaluate the new possibilities for their "fitness," and put them in competition with the previous, partially effective solutions. The computer also "mates" the various solutions, that is, cuts up and splices portions of bit strings that seem to code the most effective values, and then tests these "offspring" for their fitness. It works with coadjusted clusters that probably (but not inevitably) move together during crossover. It may vary the "population size" of the set of solution values that it mates. It will discard solutions with low fitness.

If two or more sets of solutions begin to appear that have little in common (widely separated local optima), the computer will preserve these multiple solution tracks, but try an occasional cross-mixing of segments from the different local optima, some of which will result in offspring that have enough fitness to remain in the working population. Such outbreeding prevents getting trapped in local optima that are not effective solutions globally. The computer will continue with lesser probability (which may be varied during the program) occasionally to explore unlikely solutions. Even in large and complicated search spaces, genetic algorithms tend to converge on solutions that are globally optimal or nearly so. Simple bit strings can encode complicated structures, and reiterated transformations of partial solutions have a striking power to improve them (Holland, 1975, 1980; Davis 1987; Goldberg, 1989; Muhlenbein, Gorges-Schlcuter, and Kramer, 1988; Whitley, Starkweather and Bogart, 1990). Computer searches for optimal solutions

that would take a computer an estimated billion years, if done completely at random, can be accomplished in a few hours.

Such genetic problem solving docs not seem so piecemeal, tinkering, blind, irrational, or ungodly. Also, what is going on in these genetic algorithm programs, mimicking the chromosomes, is not that any one "gene" is acting selfishly, but that a set of values, coded on the "genes," is being optimized through the concerted interactions of numerous information storage sites. What is being tested is the intensification or inhibition of one part of a solution (one value) coupled with the contributions of many others, all integrated (not just aggregated) in solution.

D. Trial and Error Learning

We are too swift if we think that there is no trial and error in scientific problem solving, no groping about in the dark. When R.E. Munro, a molecular biologist, reflected over the development of biology he concluded: "An essential characteristic of scientific research, in its more revolutionary aspect is that the scientist is searching for the unknown or, in other words, he does not know what he is searching for" (Munro, 1974, p. 119).

Herbert A. Simon, a cybernetics theorist, compares problem solving with natural selection, to find that, on the cutting edges of science:

> The process ordinarily involves much trial and error. Various paths are tried; some are abandoned, others are pushed further. Before a solution is found, many paths of the maze may be explored. The more difficult and novel the problem, the greater is likely to be the amount of trial and error required to find a solution. At the same time, the trial and error is not completely random or blind; it is, in fact, rather highly selective. . . . Human problem solving, from the most blundering to the most insightful, involves nothing more than varying mixtures of trial and error and selectivity (Simon, 1969, p. 95, p. 97).

The *justification* of variants, the testing of them, is indeed highly selective, but the *discovery* of variants, the generation of them, cannot be overly selective, and is perhaps not selective at all when one is really stymied about where to go next. Generate and test is standard scientific procedure (often a strategy imitated by computer programers seeking to construct artificial intelligence). Normally a scientist does want to search the nearby space for possibilities of development. On the other hand, in more radical research, a systematic search is a waste of time if you are nowhere near the zone of good answers, in which case a little

random probing around in supposedly wild places may be a useful heuristic. New ideas may be recombinations of old ideas, but they may come from places entirely out of the range of the old theory. When you go beyond the range of what is already known or suspected, you proceed blindly. There is now a kind of random trial and error, with most of the ideas worthless or irrational, but the occasional bubbling up of one that has promise. That rare, lucky idea is locked onto by rational selection, and science turns in hitherto unanticipated directions.

So what is so disvaluable about natural systems? It seems rather that there is valuable problem solving taking place. The process is not so blind and stupid as once thought; to the contrary it is a remarkable precursor of intelligent thought, with creative achievements that our human intelligence has yet to match.

III.
A RANDOM WALK
OR CYBERNETIC AXIOLOGICAL SYSTEM

A. A Random Walk?

Well, perhaps there is no selfishness in nature, rather there are values shared. Perhaps the genetic process is more clever than we supposed. Still, viewing the history of natural selection systcmically, some hardnosed scientists are reluctant to see any directions, perhaps because their theory, as usually interpreted, does not entitle them to see any. The theory says only that the better adapted survive, and, despite the use of the word "better" with adaptation, this leaves entirely open the question whether the survivors are better in any sense involving progressive worth. The theory does not say that the survivors must be more complex, perceptive, sentient, specialized, or that the ecosystems in which later-coming forms are components will be more diverse or stable than the earlier ones. Later-coming grasses or crustaceans are not any better than earlier, now extinct ones; they arc just different In climates growing colder or drier fewer species may live there later than did before.

Whether in fertile or harsh environments, the species in any ecosystem are simply buffeted about by their changing environment. If the environment has no direction, but just drifts through tectonic changes, climatic changes, continental drift, and so on, then neither can the life forms that inhabit such an environment have direction. At the molecular, genotypic level those that survive do so on the basis of random variations, unrelated to the needs of the organism; and, at the molar, phcnotypic level, though there is selection of the better adapted, the selecting environment is drifting. Species must track this environmental drift, but if the environment they track is drifting, then they do not progress toward complexity or diversity, or anything else,

they just track drift—as aimless as are geomorphic processes. Since what is selected for is fitness to survive, the only form of progress that natural selection can promote is capacity to survive, and that is an independent variable with regard to increasing complexity or increasing diversity.

The history of Earth, we are claiming, is a story of the achievement, conservation, and sharing of values. Earth is a fertile planet, and in one sense, fertility is the deepest value category of all . . .

Jacques Monod wrote,

Chance *alone* is at the source of every innovation, of all creation in the biosphere. Pure chance, absolutely free but blind, at the very root of this stupendous edifice of evolution: this central concept of modern biology is no longer one among the other possible or even conceivable hypotheses. It today is the *sole* conceivable hypothesis, the only one that squares with observed and tested fact (Monod, 1972, pp. 112-113).

Stephen Jay Gould agrees: "We are the accidental result of an unplanned process ... the fragile result of an enormous concatenation of improbabilities, not the predictable product of any definite process" (Gould, 1983, pp. 101-102).

Like a rotating kaleidoscopic, there is change without development. The biological panorama, more or less packed since Cambrian times, is a scene of steady turnover, but not really different from the astronomical panorama of the cycling planets and revolving galaxies. Natural history itself is nonprogressive, since all that is selected for is capacity to survive, unrelated to any increase of worth or value. There may result accidental values, but the system is without value heading. All we have are "chance riches" (Gould, 1980b).

B. Development of Diversity and Complexity

But something is increasingly learned across evolutionary history: how to make more kinds and more complex kinds. This may be a truth about natural history, even if neo-Darwinism, the prevailing paradigm, is incompetent to say much about how this happens. We do not think that there is any progress as the planets spin round the sun; or gases swirl around Jupiter. There is none on Earlh with the passing of cold and warm fronts; they just come and go. Likewise with the rock cycles, orogenic uplift, erosion, and

uplift again. But there is no natural selection there either, nothing is competing, nothing is surviving, nothing has adapted fit, and biology seems different. All those climatological and geomorphological agitations continue in the Pleistocene period more or less like they did in the Precambrian, but the life story is not the same all over again. Where once there were no species, now there are five to ten million. It seems evident that, on average and environmental conditions permitting, the numbers of life forms start low and end high. Diversity increases.

So does complexity. What the random walk omits is the capacity of organisms to acquire new information over historical time and to store and transmit this information. All of them start simple and some end up complex; there are trends over longer-range time scales, and something is at work additionally to merely tracking drifting environments. The life process is drifting through an information search, and locking onto discoveries. It is cybernetic or hereditary, as geomorphic processes are not; there is no cumulation of information in the hydrologic, climatological, orogenic cycles, but there is in the birth, life, death, genetic cycles. That is why biology is historical in ways impossible in physics or geophysics.

Reptiles can cope in a broader spectrum of humidity conditions than can amphibians. Mammals can cope in a broader spectrum of temperature conditions than can reptiles. Once there was no smelling, swimming, hiding, defending a territory, gambling, making mistakes, or outsmarting a competitor. Once there were no eggs hatching, no mothers nursing young. Once there was no instinct, no conditioned learning. Once there was no pleasure, no pain. Once there was no capacity to make intentional reference, but this capacity arose, as when vervet monkeys learned to give different alarm calls to indicate the approach of different kinds of predators.

J.W. Valentine, after a long survey of evolutionary history, concludes for marine environments that both complexity and diversity increase though time.

A major Phanerozoic trend among the invertebrate biota of the world's shelf and epicontincntal seas has been towards more and more numerous units at all levels of the ecological hierarchy. . . . The biosphere has become a splitter's paradise (Valentine, 1969, p. 706).

A sort of moving picture of the biological world with its selective processes that favor increasing fitness and that lead to 'biological improvement' is projected upon an environmental background that itself fluctuates. . . . The resulting ecological images expand and contract, but, when measured at some standardized configu-

ration, have a gradually rising average complexity and exhibit a gradually expanding ecospace (Valentine, 1973, p. 471).

The story of terrestrial life may be even more impressive, because the land environment is more challenging than the marine one. There are increases in capacities for centralized control (neural networks with control centers, brains surpassing mere genetic and enzymatic control), increases in capacities for sentience (ears, eyes, noses, antennae), increases in capacities for locomotion (muscles, legs, wings), increases in capacities for manipulation (arms, hands, opposable thumbs), increases in capacities for acquired learning (feedback loops, synapses, memory banks), increases in capacities for communication and language acquisition. Nothing seems more evident over the long ranges than that complexity has increased. In the Precambrian there were microbes; in the Cambrian Period trilobites were the highest life form; the Pleistocene Period produced persons.

The lower forms remain too, because life takes place only in communities in which there must be trophic pyramids, autotrophs and heterotrophs. There can be no higher forms all by themselves. These must be superposed on lower forms, embedded in communities. So there can seem only change, not progress, if we look at the monocots and dicots, the crustaceans and flatworms. Perhaps we should not expect much progress in the invertebrates, not much past that in the arthropods. In the understories, which must remain occupied if there is to be a biotic community, there is mainly turnover, perhaps with some increased fitness for survival. We certainly do not want to disrespect such forms of life; they have their own values, intrinsic, instrumental, and systemic. But to have the whole story of nature as a historical system, we must look at the uppermost forms. In the vertebrates, most of all, advance is difficult to deny.

Francisco J. Ayala concludes, "Progress has occurred in nontrivial senses in the living world because of the creative character of the process of natural selection" (Ayala, 1974, p. 353). Theodosius Dobzhansky concludes,

> Nobody has been able to propose a satisfactory definition of what counts as evolutionary progress. Nevertheless, viewing evolution of the living world as a whole, from the hypothetical primeval self-reproducing substance to higher plants, animals and man, one cannot avoid the recognition that progress, or advancement, or rise, or ennoblement, has occurred. . . . Seen in retrospect, evolution as a whole doubtless had a general direction, from simple to complex, from dependence on to relative independence of the environment, to greater and greater autonomy of individuals, greater and greater development of sense organs

and nervous systems conveying and processing information about the state of the organism's surroundings, and finally greater and greater consciousness (Dobzhansky, 1974, pp. 310-311).

I doubt whether you can be a biologist without a respect for life, and the line between respect for life and reverence for life is one that I doubt that you can always recognize.

G. G. Simpson, after surveying the fossil record extensively and noting that there are exceptions, concludes:

> The evidence warrants considering general in the course of evolution . . . a tendency for life to expand, to fill in all available spaces in the liveable environments, including those created by the process of that expansion itself.... The total number and variety of organisms existing in the world has shown a tendency to increase markedly during the history of life (Simpson, 1964, p. 243, p. 341).

Randomness is not the systemic story, however important it may be in the subplots. With such a conclusion the value question returns. If the system does produce both diversity and complexity of life, the process is as valuable as the products, indeed more so. The value question in nature becomes, on global scales, the entropy/negentropy question, that of cumulating order feeding on and overcoming disorder in the creative process.

IV.
CREATIVITY AND CREATOR

A. Self-creativity in the Creatures

We have been advocating a paradigm change in biology, anticipating that this might get biology ready to join with theology. But theology too will need to reform to get ready to join with this reformed biology. The *creative action,* once reserved to God's special creation of fixed species, must now be reallocated to include a vast self-creativity within the creatures, lured upslope over this long evolutionary process. What theologians once termed an established order of creation is rather a natural order that dynamically creates, an order for creating. The older and

newer accounts both concur that living creatures now exist where once they did not. But the manner of their coming into being has to be reassessed. God is not molding the material, craftsman-like. But God "from below" microscopically creates the energetic, prolife materials which bubble up trials. "From above," systematically and environmentally, God coaxes forth living organisms via selectivity intrinsic in the processes, and God selects the best adapted via natural selection.

The watchmaker-design approach to the concept of a Creator, if appropriate in physics, may not be the model for biology, where more autonomy and self-creativity is combined with the divine will for life, a divine parenting entwined with spontaneous creative process. Organisms defend their lives; their "selfishness," so-called, is really self-actualizing, the defense of vitality. Reproduction is the ongoing sharing of biological value and promise. The tracks (fossils) left on a sandy playground by a child whose father was teaching her to walk would seem erratic and meaningless to an outside observer, uninformed about what was going on. But they would in fact be the tracks of a significant and lovely process. The evolutionary advance, with its paleontological record, requires a still more sophisticated keying in to providential pathways.

B. Earth as Providing Ground

Every animal, every plant has to seek resources, but life persists because it is provided for in the system. Earth is a kind of providing ground. Life is a suffering through to something higher, which, seen from an earthy side, seems to be random chance, but seen from a godward side, is divine creativity. Each species is a bit of brilliance, a bit of endurance, a moment of truth, animated, spirited inventiveness. The swarms of creatures are not so much an ungodly jungle as a garden Earth, a divinely inspired Earth. Design is not the right word; it is a word borrowed from mechanics and their machines, watchmakers and their clocks. An organism is not a machine, nor a clock. Genesis is the word we want; it is a word with "genes" in it, with the gift of autonomy and self-creation. Designed machines do not have any interesting history; clocks have no story lines. But organisms must live story lines, and that epic is life lived on in the midst of its perpetual perishing, life arriving and struggling through to something higher. That story continues for several billion years; such an Earthen providing ground is, in the theological perspective, providential.

Providential adventures do not so much have design as do they have pathways. In grace accompanying a passage through history, there must be a genetic pathway available, by which survival can be maintained, and along which phenotypes can be produced in a sequence that gets from here to there by increments, some of which may be quantum increments, which natural selection can see. There has to be a lineage of descent, ascent, exploration, adven-

ture. There has to be a story line over which the new skills or structures can be achieved. It is not enough that there be ideal form; there must be history that can reach the form. Monotheists who take genesis seriously, who take creation vitally, do not suppose a *Deux ex machina* that lifts organisms out of their environment, redesigns them, and reinserts them with an upgraded design. Rather they find a divine creativity that leads and lures along available routes of Earth history.

C. Law, Grace, and Natural History

Laws are important in natural systems, but natural law is not the complete explanatory category for nature, any more than is randomness and chance. In nature, beyond the law is grace. Life is a kind of gift. There is creativity by which more comes out of less. Though the system provides for it, no logic demands it. No theory predicts it Actually, science does not handle historical explanations very competently, especially where there are emergent novelties; science prefers lawlike explanations in which there are no surprises. One predicts, and the prediction comes true. But nevertheless biology is full of unpredictable surprises. The account of natural history will not be by way of implication, whether deductive or inductive. There is no covering law (such as natural selection), plus initial conditions (such as trilobites), from which one can deduce primates, any more than one can assume microbes as a premise and deduce trilobites in conclusion. Nor is there any induction (expecting the future to be like the past) by which one can expect trilobites later from procaryotes earlier, or dinosaurs still later by extrapolating along a regression line (a progression line!) drawn from procaryotes to trilobites. There are no humans invisibly present (as an acorn secretly contains an oak) in the primitive eucaryotes, to unfold in a lawlike or programmatic way. All we can do is tell the epic story—eucaryotes, trilobites, dinosaurs, primates, persons who are scientists, ethicists, conservation biologists—and the drama may prove enough to justify it.

We want a genetic account in the deeper sense, one that tells the full story of the historical genesis of value. The history of Earth, we are claiming, is a story of the achievement, conservation, and sharing of values. Earth is a fertile planet, and in one sense, fertility is the deepest value category of all, one classically reached by the category of creation. In fact, what is there is a systemic process, profoundly but partially described by evolutionary theory, a historical saga during which spectacular values are achieved and at the core of which the critical category is value (not selfishness), commonly termed "survival value," better interpreted as valuable information, coded genetically, that is apt for "living on and on" *(sur-vival),* for coping, for life's persisting in the midst of its perpetual perishing. Such fecundity is better interpreted still as divine creativity.

Although this history has been a struggling through to achieve something higher (which evolutionary theory can only model as better adapted fit), there is no particular cause to assume that the grim accounts of it are the adult, biologically correct ones, and the gracious, creative, charismatic ones are childish, naive, or romantic. Indeed the latter accounts are romantic in the classical sense, the adventurous epic of life lived and loved in its rich historical novelty.

D. Genesis and Creativity

Whatever you may make of God, biological creativity is indisputable. There is creation, whether or not there is Creator, just as there is law, whether or not there is a Lawgiver. Sometimes biologists decline to speak of creation, because they fear a Creator lurking in the concept of creation. Well, at least there is genesis, whether or not there is a Genitor. Ultimately, there is a kind of creativity in nature demanding either that we spell nature with a capital N, or pass beyond nature to nature's God. Biologists today are not inclined, nor should they be as biologists, to look for explanations in supernature, but biologists nevertheless find a nature that is super! Superb! Science teaches us to eliminate from nature any suggestions of teleology, but it is not so easy for science to talk us out of genesis. What has managed to happen on Earth is startling by any criteria. Biologists may doubt whether there is a Creator, but no biologist can doubt genesis.

In this deeper sense, says Ernst Mayr, though hostile enough to traditional monotheism, "virtually all biologists are religious, in the deeper sense of the word, even though it may be a religion without revelation. . . . The unknown and maybe unknowable instills in us a sense of humility and awe" (Mayr, 1982, p. 81). Loren Eiscley concludes at the end of *The Immense Journey,*

> I would say that if 'dead' matter has reared up this curious landscape of fiddling crickets, song sparrows, and wondering men, it must be plain even to the most devoted materialist that the matter of which he speaks contains amazing, if not dreadful powers, and may not impossibly be ... 'but one mask of many worn .by the Great Face behind'" (Eiscley, 1957, p. 210).

The molecular self-assembling is a sort of self-actualizing, but it is also a response to the brooding winds of the Spirit moving over the face of these earthen waters.

In a stunning volume of photographs and existential reflections produced by the space explorers, a pivotal and repeated theme is the awe experienced at the first sight of the whole Earth (Kellcy, 1988). Though these hundred and more astronauts come from many cultures and countries, their virtually unanimous experience is religious, of being grasped, shaken, and transformed by an astonishing encounter. Viewing the fertile Earth, they get in space something of the experience that biologists get in time—a glimpse of divinity.

Annie Dillard, who herself can be religious enough in other moments, is sometimes terrified at the evolutionary ordeal. Overlooking the long and odious scene of suffering and violence, she cries out: "I came from the world, I crawled out of a sea of animo acids, and now I must whirl around and shake my fist at that sea and cry shame" (Dillard, 1974, p. 177). Must she? There is nothing shameful about amino acids rising out of the sea, speciating, swarming over Earth, assembling into myriads of species, not the least of which is *Homo sapiens,* with mind to think and hand to act. If I were Aphrodite, rising from the sea, I think I would turn back to reflect on that event and raise both hands and cheer, rather than shake a fist in shame. And if I came to realize that my rising out of the misty seas involved a long struggle of life renewed in the midst of its perpetual perishing, I might well fall to my knees in praise. Nature is not some kind of night and darkness; exactly the opposite: "Nature is one vast miracle transcending the reality of night and nothingness" (Eiselcy, 1960, p. 171).

When J.B.S. Haldane found himself in conversation with some theologians and was asked what he had concluded from his long studies in biology about the character of God, he replied that God had an inordinate fondness for beetles. God must have loved beetles, he made so many of them. But species counts are only one indication of diversity, and perhaps the fuller response is that God must have loved life, God animated such a prolific Earth. Haldane went on to say that the marks of biological nature were its "beauty," "tragedy," and "inexhaustible queerness" (Haldane, 1932, pp. 167-169). This beauty approaches the sublime; the tragedy is perpetually redeemed with the renewal of life, and the inexhaustible queerness recomposes as the numinous. Biology produces many doubts; here are two more. I doubt whether you can be a biologist without a respect for life, and the line between respect for life and reverence for life is one that I doubt that you can always recognize. If anything at all on Earth is sacred, it must be this enthralling creativity that characterizes our home planet. If anywhere, here is the brooding Spirit of God.

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