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Darwin Versus Copernicus

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About three centuries ago, Pascal described the human condition with a lucidity and poignancy never since equaled:

> When I consider the short duration of my life, swallowed up in the eternity before and after, the little space which I fill, and even can see, engulfed in the infinite immensity of spaces of which I am ignorant and which knew me not, I am frightened, and am astonished at being here rather than there; for there is no reason why here rather than there, why now rather than then. Who has put me here? By whose order and direction have this place and this time been allotted to me? The eternal silence of these infinite spaces frightens me.

Whether the silence of the infinite spaces is more or less frightening to our contemporaries than it was to Pascal is hard to tell. The spaces still know us not, but we begin to know something about the spaces. By whose order this place and time have been allotted to me has, however, become, if anything, still more mysterious.

Objects most remote from us yet discovered in the universe are galaxies some five billion light-years away. The mysterious quasars (quasi-stellar objects), or some of them, may be as remote, but their nature and remoteness are still under dispute among cosmologists. This is a remoteness which staggers the imagination; the radiation from these objects reaching us today left its source billions of years ago. The universe is believed to have started in a "Big Bang," a cosmic explosion which made the universe "expand," or rather caused its different components to fly apart in all directions with colossal speeds. The date of the Big Bang, and [131] consequently the supposed age of the universe, is estimated to be on the order of fifteen billion years. These estimates tend, however, to be lengthened rather than shortened by newer discoveries.

The number of galaxies in the universe visible in the 200-inch telescope is estimated to be close to one billion. Our galaxy is merely one of these, yet it may contain between one million and one hundred million planetary systems. One of these includes a medium-sized planet which we inhabit. The supposition that the planet earth is in any way unique or exceptional or privileged seems farfetched to many scientists. It is, however, the only one known for certain to have a tiny proportion of its mass involved in a process called life. Moreover, the diversity of living beings is very impressive. There are at least two million kinds, or species, of

life on earth at present, and there were more in the past, which became extinct.

Speculation is rife concerning the possibility that there may be life of some sort on other planets, in other planetary systems, and in other galaxies. Some authorities go so far as to proclaim it a certainty that life not merely could, but must have arisen in many places in the universe. More than that, sentient and rational beings must have evolved on many planets where there is life. In other words, "We are not alone." The name "exobiology" has been invented for the study of the assumed extraterrestrial life. The problems of exobiology cannot be adequately discussed here; I realize that the following remarks may do injustice to the ingenious speculations advanced in this field. I cannot, however, help wondering if the exobiologists may not turn out to be high-powered specialists on a nonexistent subject. The stock argument in favor of the existence of life in many places in the universe runs about as follows: Although the critical step from the nonliving to the living may be a rare and improbable event, there are some one hundred million planets in our galaxy on which this step could be made, hence it must have been made on several or even on many. This argument is not really convincing, however, because nobody knows for sure just how probable or improbable the event may be under various circumstances. It is certain that the event happened at least once— on earth. The evidence that it was not a unique event is yet to be obtained— it cannot be taken for granted.

Let us, however, assume for the sake of a further argument that life did arise in many places, and moreover that it was life based on nucleic acids and proteins, in other words, life chemically of the same kind as that on earth. This granted, it far from follows that such life must have evolved elsewhere as it did on our planet, let alone that it must have produced [132] humanoid organisms. Evolution is principally adaptation to the environment; however, even if the environments somewhere happened to be much like, though of course not identical with, those on earth, a reenactment or repetition of the terrestrial evolutionary history has a probability very close to zero. This is because biological evolution is not predetermined to achieve any particular form of adaptedness to the environment. It has a range of possibilities that is virtually unlimited.

Evolution is a creative process which is most unlikely to occur two or more times in the same way. Man was not contained in the primordial life, except as one of an infinitely large number of possibilities. What these other unrealized possibilities might have been we probably shall never know. And yet, the origin of man was not an accident either, unless you choose to consider all history, including biological history and that of human societies, states, and nations, as series of accidents. This is a possible view, but not an appealing one. It is far more meaningful to describe biological and human histories as successions of unique events, each event being causally related to what went on before and to what will follow in the future, and yet nonrecurrent. George Simpson gave arguments essentially similar to the above in a brilliant article entitled "The Non-prevalence of Humanoids," that is, nonprevalence anywhere except on our planet. Our species, mankind, is almost certainly alone in the universe. And to that extent, our planet is also unique.

To recognize this "aloneness" is not necessarily to experience the Pascalian "fright" and "astonishment." Quite the opposite. The space which mankind fills, and the duration of its existence so far, are indeed very small compared to the now known "immensity of spaces." The messages that we may wish to send describing human activities on earth may have to travel billions of years at the speed of light to reach the quasars and the remotest galaxies. And there is probably nobody there to receive these messages. Does it mean that all our doings, both those of individuals and of the human species as a whole, are mere whiffs of insignificance? Not at all; because it is unique, the career of the human species here on earth may be of cosmic sig-

nificance. This idea need not be a wildly conceited delusion. Our species may well be alone in having discovered that the universe and all that it contains, including mankind, is a changing product of evolution. It is neither size nor geometric centrality in the solar system, or in our galaxy, or in the universe, that makes the planet earth so important. It is that the flames of self-awareness, of death awareness, and of evolutionary awareness have been kindled here on earth and probably nowhere else. [133] The image of man as seen by Pascal and his contemporaries and successors is different from that emerging from evolutionary science. The difference becomes understandable when viewed against the background of the history of science and of its philosophical implications since Copernicus, Galileo, Newton, and Darwin. Here again I am forced to be too brief and, I fear, too dogmatic. The pre-Copernican man felt certain not only that he was the heart of the universe but that the universe was created for him and because of him. The earth was the hub of several concentric spheres: those of the moon, of the sun, of the planets, and of fixed stars. God watched the smallest happenings on earth from somewhere up above. The interior of the earth contained an elaborately engineered hell; a man could avoid becoming its resident in perpetuity only by good behavior during his brief sojourn on the earth's surface, and by the intercession of the properly constituted ecclesiastic authorities. With travel difficult and slow, the earth seemed to be very large. It shrank progressively as it was gradually explored and as travel became easy and rapid. It is quite small in the age of jet aircraft. But whether large or small, the earth existed for man and for the realization of God's mysterious plans for man's salvation.

All these arrangements did not make man free of anxieties. He faced the *mysterium tremendum*—why has God arranged things as he has? This was, however, just one extra mystery—the greatest one to be sure—but mysteries were all around, from the vagaries of weather to the behavior of one's friends and enemies. All these things were the doings of spirits, good or evil. Though spirits were more powerful than men, men were not entirely defenseless against them, because one could secure the assistance of some spirits against others.

The development of science changed the situation. At first sight, the mystery began to recede; but in fact it was relegated to the beginning of the world. Copernicus, after him Kepler and Galileo, and still later Newton, together with their many followers and successors, changed the image of the universe and of man. The earth is a smallish planet revolving around a much grander sun. Instead of the celestial spheres there is only the endless void, in which other planets, suns, and galaxies are as tiny islets on an infinite ocean. Man is lost in cosmic spaces. It is not, however, the dimensional smallness of man that really matters. It is rather the mechanical and inexorably deterministic nature of the universe, and finally of man himself, that changes man's image. Celestial phenomena are calculable and predictable, provided that one has discovered the precise and eternal laws which they obey. Biological and psychological phenomena are less predictable, but only because they are much more complex and the laws [134] governing them are yet to be discovered. Descartes decided that the human body was as much a machine as a clock or other "automation," although he still believed that man had a non-mechanical soul. Others found the hypothesis of soul to be superfluous. Man is a machine, and that is that.

God was found to be another superfluous hypothesis. To be sure, Newton and many other scientists tried to hold onto their religions. Newton thought that the planets were hurled into their paths initially by God. But subsequent to this divine act at the beginning, the planets follow their proper orbits, according to immutable laws and without further guidance. The deists thought that God was the original creator and lawgiver of the universe. Having created the universe and set it in motion, God found it so well made that his presence became no longer essential. Instead of mysteries, we have the

laws of nature. Some people thought that God reserves the right of occasional miraculous intervention, temporarily abrogating the very laws which he himself has formerly established. To others such behavior appears unseemly for the all-wise and omniscient Creator. It is more convenient to imagine him as a sort of absentee landlord, who lets things take their "natural" courses.

Mystery driven out through the front door tends to creep in through the back door. Has the Creator and Lawgiver arranged things really well? If he is credited with the order, beauty, and goodness in the world, he must by the same token be responsible also for the disorder, ugliness, and evil. The machinery of the world has serious flaws, and this is a mystery defying comprehension. An absentee-landlord god can hardly be prayed to, since he is unable or unwilling to intervene to change the causal sequences which bring about events.

To this is added the hopelessness of determinism. As stated by Laplace, the doctrine of determinism is essentially that if one knew the position and speed of every particle in the universe at any single instant, and if one could submit this knowledge to analysis, then one could predict all future events and also retrodict all past events. Although this statement contains two pretty vertiginous "ifs," determinism is an explicit or implicit faith which is the basis of scientific activity. It leads, however, to an embarrassing inference: there is nothing new in the world, because all that ever happens was predestined to happen from the beginning. No human effort, or absence of effort, can change anything, because the effort or its absence is equally predestined. This is a far stronger fatalism than the fatalism sometimes (and mostly wrongly) ascribed to oriental philosophies.

Darwin has been called the Newton of biology, although the [135] Copernicus or the Galileo of biology would perhaps be a better characterization. There is as yet nothing in biology analogous to, say, the laws of gravitation; the Newton of biology may be yet to come. To say this is not to underestimate Darwin's contribution. He has shown that the biological species, including man, have not appeared ready-made; their multifarious structures and functions are not mere whims of nature or of a Creator. Every living species is a descendant of ancestors unlike itself, and generally more unlike the farther back in time one looks. It is probable, though not certain, that all beings now alive are descendants of one primordial life which appeared some four billion years ago. Presumed remains of living beings three and one-half billion years old have recently been found. The organic diversity is a consequence of adaptation to different environments; the endless variety of bodily structures and functions makes possible an endless diversity of modes of life. There are so many kinds of organisms because they can exploit more fully the diverse opportunities which an environment offers for living than any single organism conceivably could.

The human species has evolved a unique way to cope with its environments. This way is culture. Culture is not transmitted from generation to generation by the genes, although its biological basis is so transmitted. Culture has been called "superorganic," although it surely rests on an organic foundation. Man is an animal, but he is so extraordinary that he is much more than an animal. Darwin and his successor evolutionists have thus extended to the living world, and even to the human world, the principles which were shown to be so supremely efficient in the study of the physical world. Biology has by now exorcised the ghost of vitalism, which wanted to see in life something radically incommensurable with the rest of nature. Mechanism has triumphed in biology. This triumph was what Darwin and the evolution theory were, and still are, mainly acclaimed for. There is, however, another aspect to evolutionism which may be at least equally and possibly more important. It sees the whole universe, and everything in it, in the process of change and development. The universe is on its way to somewhere. Where is it going?

The grandeur of the Newtonian image

of the universe was in its serene constancy and the precision of its laws. Planets and their satellites follow their orbits again and again, in predictable fashion. Moreover, since Newton accepted the traditional creation date as well as the apocalyptic prediction of the end of the world, there was little opportunity for change either in the past or the future. The laws of the conservation of mass and of energy were discovered later; here was a break in the constancy, however [136]—although energy is conserved, it undergoes a directional change because of entropy.

What biological evolution is all about, however, is not constancy but change. Darwin and his successors have shown that the living world of today is different from what it was in the past, and that it may become different again in the future. Mankind proved to have a hitherto quite unsuspected kind of history. This is the history of its slow emergence from its animal ancestors in addition to the recorded history of patriarchs, kings, battles, and empires. And while recorded history goes back only a few thousand years, biological history extends somewhere between one and a half and two million years. But even this history is short relative to that of the life from which man came, which took perhaps four billion years. And back of that are more billions of years, when the universe existed without either life or man.

I do not wish to be understood as claiming that it was Darwin who made evolution into a universal principle. In point of fact, it was recognized before Darwin that the planetary system has had a history of origin from the primitive sun, or from a mass of matter which gave origins both to the sun and to the planets. Human history has been studied at least since Herodotus and Thucydides; late in the eighteenth century Condorcet ascribed to it a directional character—from a primitive barbarianism to an earthly paradise of perfect enlightenment. Darwin's theory of biological evolution is, however, the keystone of the evolutionary conception of the world, beginning with the evolution of the cosmos and culminating in the evolution of mankind. Modern cosmology is evolutionary cosmology. Even the atoms of the chemical elements, hitherto symbols of indivisibility and unchangeability, proved to have had an envolutionary history. In the homely language of some modern cosmologists, the atoms were "cooked" in the Big Bang at the start of cosmic evolution, and they are still being cooked in the furnaces of the interior of the sun and of the stars.

It has been urged by some authorities that the term "evolution" should be restricted to biological evolution only. I do not share this view, because it seems to me important to convey the idea that change and development are characteristic of nonliving as well as of living matter and of human affairs. This does not prevent one from recognizing that the processes of cosmic, inorganic, or geological evolution are different from biological evolutionary processes. The causes of biological evolution must be looked for in heredity, mutation, and natural selection. None of these is found in nonliving systems, and the analogies which some authors have attempted to [137] draw are at best remote. Other analogues of heredity, mutation, and natural selection have been claimed in human social and cultural evolution with, I fear, even less success. These analogies are more often obfuscating than enlightening.

Nor can I see much of an advantage in the views expounded so brilliantly by such philosophers as Whitehead and Hartshorn. They like to ascribe to inorganic systems, and even to atoms and subatomic particles, some rudiments of life, individuality, and, further, of consciousness and volition. It is almost needless to say that there is no positive evidence, either compelling or presumptive, of any such biological and human qualities in nonliving systems. Even as a speculative possibility these views do not seem to me attractive. They really amount to a denial of anything substantially new ever arising in evolution. They are most nearly analogous to the early preformistic notions in biology; some eighteenth-century biologists believed that a sex cell contains a "homunculus," a tiny figure

of man. This seemed to make the problem of development very simple—the homunculus had only to grow in size to become an adult man, and a corresponding miniature in an animal sex cell had to grow to become an adult animal of the proper species. But this simplicity was deceptive, since it made the problem of the development of succeeding generations insoluble. One had to believe that homunculi contained second-order homunculi, these had third-order homunculi, and so on, ad infinitum. An analogous difficulty arises with the "minds" of atoms. It might seem at first that human mind could simply evolve by growth of the atomic mind. Human mind is, however, somehow associated with the human brain, and where are the brains of atoms and electrons?

The most interesting aspect of evolution is precisely that it creates novelties. From time to time it transcends itself, i.e., produces novel systems with novel properties—properties which the antecedent systems did not have even as tiny germs. The emergence of the living from the nonliving, and the emergence of humanity from animality, are the two grandest evolutionary transcendences so far. Teilhard de Chardin was the evolutionist who had the courage to predict further transcendences, mankind moving toward what he called the megasynthesis and toward Point Omega, this last being his symbol for God. Here is evidently a borderland, in which Teilhard's science has collaborated with his mystical vision. I am not planning in the present discussion to take you on an excursion in this borderland of prophecy.

As already stated above, we do not know for sure whether the [138] transcendences of the nonliving to life, and of animal to man, have taken place solely on this planet earth or in many places in the universe. Perhaps some positive information bearing on this issue will come from the progress in space travel. Be that as it may, we do have conclusive enough evidence that these three kinds of evolution, inorganic, organic, and human, have happened here on earth. These three kinds of evolution are not independent of each other; they are rather the three stages of the single Evolution of the cosmos. By calling them "stages," I do not mean to suggest that cosmic evolution stopped when the biological phase started, or that biological evolution stopped when the human phase began. On the contrary, the three kinds of evolution are not only going on, but what is more, they are connected by feedback relations. For example, geography influences the living things which inhabit a given territory; in turn, vegetation, animals, and especially human activities have now become geographic and even geologic agents. Human cultural evolution influences mankind's genetic endowment, and vice versa. In recent years there have been publicized some alarmist views, asserting that human genetic endowment is in a process of degeneration, and predicting dire consequences of this for the future. This matter cannot be adequately discussed in this article; I believe that the dangers have been exaggerated, and in any case the situation is not beyond possible control.

The evolutionary view of the world does not abrogate the classical Newtonian mechanistic view. The change which evolutionism makes is nevertheless of greatest importance for man's view of himself and of his place in the universe. The classical conception stressed the essential permanence of things, at least for the duration of the world's existence. The evolutionary conception emphasizes change and movement. The preevolutionary world view did not, of course, deny all change; but the changes were usually represented as cyclic, and the world as a whole did not go anywhere in particular. Spring, summer, autumn, and winter return again and again at the appointed times; people are born, grow, build families, get old, and die, and a new generation goes through the same succession of stages; plants and animals, like people, produce generation after generation; heavenly bodies follow their orbits again and again; mountains rise, are eroded away, become submerged in the sea, rise up again, etc., etc., etc. ... But to translate a French adage, the more things change the more they remain the same.

Constancy, lack of change, and regular recurrence seem to be reassuring and comforting to many people. "Like the good old days" is a [139] compliment tinged with nostalgia. Change brings insecurity; one has to become adapted, adjusted, or reconciled to altered situations. Yet changelessness, or eternal repetition or return, is the acme of futility. A world which remains forever the same is senseless. It is what Dostoevsky called a "devil's vaudeville." All the strivings and struggles which a person, or a generation, has to go through are in vain because the next generation, and the one after that, and so on ad infinitum, will have to go through the same struggles all over again.

What difference does the idea of evolution make? Quite simply, it is this: the universe is not a status but a process. Its creation was not something which happened a few thousand years ago, before any of us were born and could have influenced it in any way. The creation is going forward now, and may conceivably go on indefinitely. The view that "there is nothing new under the sun" is in error. In the past there were an earth and a sun different from the present ones, and there will be a new earth and a new sun in the future. An important role in this forward movement belongs to the phenomenon called life, and to one particular form thereof called mankind, which exists as far as we know only on a single and not otherwise remarkable planet.

The evolution of life is remarkably rapid, measured on a cosmic time scale. Ten million years ago, the oceans and mountains, the moon, the sun, and the stars were not very different from what they are now, but the living beings inhabiting the earth were rather unlike the present ones. Ten thousand years ago mankind was quite different from what it is now, while except for the destruction of some biological species, the biological world was pretty much what we now observe. Evolution is a creative process; the creativity is most pronounced in human cultural evolution, less in biological, and least in inorganic evolution.

A creative process by its very nature always risks ending in a failure or being stranded in a blind alley. Every biological species is nature's experiment, essaying a new mode of living. Most species eventually prove unsuccessful and become extinct without issue. Yet some, a minority, discover new or superior ways of getting a living out of the environment which is available on earth. These few lucky discoverers inherit the earth and undergo what is technically known as adaptive radiation. That is, the surviving species differentiate and become many species again, only to repeat the process of discovery, extinction, and new adaptive radiation. Yet this is not another specimen of eternal return. New adaptive radiations do not simply restore what there was earlier; the new crop of species may [140] contain some which have achieved novel or surer ways of remaining alive, or have discovered previously unexploited niches in the environment and have thus augmented the living at the expense of the non-living.

The trial-and-error process of proliferation of ever-new species and of disappearance of the old ones has achieved remarkable successes. Biological evolution has transcended itself by giving rise to man. Mankind as a species is biologically an extraordinary success. It has gained the ability to adapt its environments to its genes, as well as its genes to its environments. This ability stems from a novel, extragenetically transmitted complex of adaptive traits called culture. Culture leads to still another kind of discovery, discoveries of knowledge, which can be transmitted to succeeding generations again by means of the extragenic processes of instruction and learning. One of the discoveries which became known is the discovery of evolution. Man knows that the universe and life have evolved, and that mankind entered this universe by way of evolution. With perhaps a bit too much poetic license, it has been said that man is evolution having become conscious of itself. It is no poetic license, however, to say that having discovered evolution, man has opened up a possibility of eventually learning how to control it.

The enterprise of creation has not been

completed; it is going on before our eyes. Ours is surely not the best of all thinkable worlds, and, we hope, not even the best of all possible worlds. Man is constantly asking whether his existence, and that of the universe in which he finds himself, has any sense or meaning. If there is no evolution, then all is futility— human life in particular. If the world evolves, then hope is at least possible.

An uncomfortable question inevitably presents itself at this point. Can science ever discover meaning in anything, and is a scientist entitled even to inquire about meanings and purposes? To a rigorous mechanicist who does not wish to think in evolutionary terms, such words as meaning, improvement, progress, and transcendence are meaningless noises. Everything in the world, including myself, is an aggregation of atoms. When this aggregation disaggregates, the atoms will still be there and may aggregate into something else. Is there an objectively definable difference between an object of art and a junk heap? If a virus and a man are nothing but different seriations of the nucleotides in their DNA's and RNA's, then all of evolution was a lot of sound and fury signifying nothing.

One of the exasperating phenomena of the intellectual history of mankind is politely called "the academic lag." This crudely mechanistic world [141] view was acceptable in science chiefly during the eighteenth and nineteenth centuries. It had justified itself by having given a powerful impetus to scientific discovery. It is now being displaced by the evolutionary world view. Yet the representatives of what C. P. Snow has referred to as literary or nonscientific culture have only recently discovered that the world is nothing but an aggregation of atoms. It is a curious experience to hear an artist argue that a junk heap is, indeed, no less worthy of aesthetic appreciation than is the "Venus de Milo," because both are matter wrought into arbitrary shapes; or to have an eminent musician declare that the atonality and certain other characteristics of avant-garde music are merely recognition of the Copernican discovery that man is not the center of the universe; or finally to read in a book by an intellectual pundit that "something pervasive that makes the difference, not between civilized man and the savage, not between man and the animals, but between man and the robot, grows numb, ossifies, falls away like black mortified flesh when techne assails the senses and science dominates the mind."

In reality science is neither a villain debasing human dignity nor the sole source of human wisdom. In Toynbee's words:

> Science's horizon is limited by the bounds of Nature, the ideologies' horizon by the bounds of human social life, but the human soul's range cannot be confined within either of these limits. Man is a bread-eating social animal; but he is also something more. He is a person, endowed with a conscience and a will, as well as with a self-conscious intellect. This spiritual endowment of his condemns him to a life-long struggle to reconcile himself with the Universe into which he has been born.

The fact that the universe was evolved and is evolving is surely relevant to this reconciliation. The advent of evolutionism makes it necessary to ask a new question which simply could not occur to those who believed that the world is created once and for all, stable and changeless.

The question is, Where is evolution going? This question can be asked separately about the three known kinds of evolution— cosmic, biological, and human. It has also been asked about evolution as a whole, because the three kinds of evolution can be viewed as the constituent parts, or stages, of a single all-embracing process of universal evolution. This universe, so formidable and so beautiful, is in a process of change. It may be that evolution is merely drifting at random, and is going nowhere in particular. There is, however, also a possibility, for which no rigorous demonstration can be given, that universal evolution is one grand enterprise, in which [142] everything and everybody are component parts. Whose enterprise is this, and with what aim and for

what purpose is it undertaken? The four centuries of the growth of science since Copernicus have not dispelled this mystery; the one century since Darwin has made it more urgent than ever.

What role is man to play in evolution? Is he to be a mere spectator or, perchance, the spearhead and the eventual director? There are people who will shrug this question off, or will recoil from it, considering it an exhibition of insane arrogance. Since, however, man is one and presumably the only rational being who has become aware that evolution is happening, he can hardly avoid asking such questions. For the issue involved is no less than the meaning of his own existence. Does man live just to live, and is there no more sense or meaning to him than that? Or is he called upon to participate in the construction of the best thinkable universe?