

Credo

OUR COSMIC HERITAGE

by *Eric J. Chaisson*

Abstract. My conclusions are threefold: The subject of cosmic evolution is my religion. The process of change itself (especially developmental change) is my God. And global ethics and a planetary culture, which cosmic evolution mandates, are the key to the survival of technologically competent life forms, both here on Earth and perhaps elsewhere in the Universe.

Keywords: change; cosmos; ethics; evolution.

I am an astrophysicist, which means that I have been trained in physics and that I have adopted the Universe as my laboratory. I feel fortunate to be a space scientist at this stage in human history, for I imagine that when our great-grandchildren gain perspective on the last portion of the twentieth century, they will likely conclude that we now share a golden age of astrophysics. I say this because the number and diversity of discoveries currently being made are (shall I risk it?) astronomical. In particular, we are currently exploring all the remaining parts of the electromagnetic spectrum, thereby granting us some early glimpses of invisible radiation, including radio, infrared, and ultraviolet waves, as well as X and gamma rays. In hardly more than a single generation—not the generation of our parents and not that of our children, but *our* generation—astronomers are now revealing the invisible cosmos much as Galileo first sampled magnified light from visible astronomical objects. The result is unsurpassed intellectual

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excitement concerning the nature of the Universe as well as of our role in it.

At the same time, I suggest that future historians will probably judge that we also now share a golden age of biochemistry. The rapid pace and penetrating insight of novel breakthroughs in the biological sciences in many ways equal the impressiveness of those of the physical sciences. The unraveling of life's code and the advent of genetic engineering, to cite but a couple of advances, herald a renewed vigor within the biochemical community.

Actually I am doubly fortunate, for in my research and teaching, I have contributed to each of the interdisciplines of astrophysics and biochemistry, and, furthermore, I have recently been attempting to synthesize these two subjects into an even grander transdiscipline that I call *cosmic evolution*. Simply defined, cosmic evolution is the study of change through time. More specifically, cosmic evolution is the study of the many varied changes in the assembly and composition of energy, matter, and life in the Universe.

Now I realize that a considerable fraction of the world's populace, most notably in the United States, can become emotional, even irate, and occasionally convulsive at the mention of the word *evolution*. Let me assure even this distinguished audience that evolution implies neither dogmatism nor atheism. Evolution is hardly more than a fancy word for change, especially developmental change. Indeed, it seems that change is the hallmark for the origin, development, and maintenance of all things in the Universe, animate or inanimate. Change has, over the course of all time and throughout all space, brought forth, successfully and successively, galaxies, stars, planets, and life. Thus, we give this process of universal change a more elegant name—cosmic evolution, which for me includes all aspects of evolution: particulate, galactic, stellar, elemental, planetary, chemical, biological, and cultural.

Broadly conceived in this way, cosmic evolution is not confined to those changes within and among astronomical objects. Rather, it encompasses all change, on every spatial and temporal domain—large and small, near and far, past and future. As such, the familiar subject of biological evolution becomes just one subset of a broader evolutionary scheme encompassing much more than mere life on Earth.

Nor is cosmic evolution in my view an attempt to extend the Darwinian principle of natural selection to realms beyond life forms. Rather, it is the search for (let me say pretentiously, perhaps arrogantly) some principle that transcends Darwinian selection; a search for a physical law that conceives, orders, and maintains all structure in the Universe, in short a search for a principle of cosmic selection.

For me, cosmic evolution is an attempt to build a cosmology in which life plays an integral role. It is an attempt to frame a heritage—a cosmic heritage—a sweeping structure of understanding based on events of the past (for as we look out in space we probe back in time), an intellectual road map identified and embraced by humans of the present, indeed a virtual blueprint for survival if adopted by our descendants of the future.

In effect (though I again acknowledge its implied arrogance, yet it is the most succinct description I can currently offer), with cosmic evolution as the core, we are trying to create a new philosophy, a scientific philosophy. And I hasten to emphasize the adjective “scientific,” for, unlike classical philosophy, observation and experimentation are vital features of this new effort. To be sure, I wholeheartedly subscribe to the notion that neither thought alone nor belief alone will ever make the unknown known. Cosmic evolution is designed to address the fundamental and age-old questions that philosophers and theologians have traditionally asked, but to do so using the scientific method and especially the instruments of state-of-the-art technology.

Indeed, the same technology that threatens to doom us now stands ready to probe meaningfully some of the most basic issues: Who are we? Where did we come from? How did everything around us, on Earth and in the heavens, originate? What is the source of order, form, and structure characterizing all things material? How did (and does) order emerge from chaos in light of the second law of thermodynamics which dictates that the Universe becomes increasingly randomized and disordered? Of ultimate import, armed with a renewed and quantified perception of change, physicists now seem poised to explain the origin of the primal energy at creation itself, and thus to tackle the fundamentally fundamental query, to wit, Why is there something rather than nothing?

BROADEST VIEW OF THE BIGGEST PICTURE

Consider the arrow of time—the archetypical illustration of cosmic evolution. Regardless of its shape or orientation, such an arrow represents an intellectual road map of the *sequence* of events that have changed systems from simplicity to complexity, from inorganic to organic, from chaos to order. That sequence, as determined from a substantial body of post-Renaissance observations, is galaxies first, then stars, planets, and eventually life forms. In particular, though I seek not to make any grand allusions to time-honored systems of western thought, I have often maintained that we can identify seven major construction phases in the history of the Universe. They are particulate evolution, galactic evolution, stellar, planetary, biochemi-

cal, cultural, and future evolution. As such, the modern subject of biological evolution, neo-Darwinism, is just one segment (albeit an important one) of a much broader evolutionary scheme stretching across all of space and all of time. In short, what Darwin once did for plants and animals, cosmic evolution does for all things. And if Darwinism created a veritable revolution in understanding by helping to free us from the anthropocentric belief that humans basically differ from other life forms on our planet, then cosmic evolution is destined to extend that intellectual revolution by in turn releasing us from regarding matter on Earth and in our bodies any differently from that in the stars and galaxies beyond.

I dare say that we can now trace a thread of understanding linking the evolution of primal energy into elementary particles, the evolution of those particles into atoms, in turn of those atoms into galaxies and stars, the evolution of stars into heavy elements, the evolution of those elements into the molecular building blocks of life, of those molecules into life itself, of advanced life forms into intelligence, and of intelligent life into the cultured and technological civilization that we now share.

By most accounts, the Universe began with the explosion of something hot and dense—hotter than the tens of millions of degrees Celsius in the cores of most stars, denser than the trillions of grams per cubic centimeter in the nucleus of any atom. Precisely what that “something” was, we cannot currently say with much certainty. Perhaps nothing more than a bolt of energy. Or perhaps nothing at all, if some of the latest physics harbors any measure of truth. And why that something exploded, we really do not know. The origin itself resembles the “Here there be dragons” school of ancient cartography. Still, people persist in asking, “What happened before the bang?” Frustrated, I often resort to Augustine who, when he considered the question, “What was God doing before he created heaven and earth?” quipped, “God was creating hell for people who ask such questions.”

With time’s passage, the Universe changed rapidly. Of foremost importance, it cooled and thinned. Sometime between the first few minutes and the first million years (the nature of the physical process was gradual) the elementary particles of matter became clustered. Electrical forces bound the particles into atoms; the weakened energy could no longer break them apart. In effect, matter had gained some leverage over the previously dominating energy. I regard this change from energy-dominance to matter-dominance as the first of two preeminent events in the history of the Universe.

Once the so-called Matter Era had successfully emerged from what was previously the Energy Era, matter effectively controlled radiation.

And it has dominated radiation ever since, successively forming galaxies, stars, planets, and life. But advanced life is special, and that is not an anthropocentric statement.

We can legitimately reason that technologically competent life differs fundamentally from lower forms of life and from other types of matter scattered throughout the cosmos. We are different because we have learned to tinker not only with matter but also with evolution. Whereas previously the gene (strands of DNA) and the environment (be it stellar, planetary, geological, or cultural) governed evolution, we humans on planet Earth are rather suddenly gaining control of both these agents of change. We are now tampering with matter, diminishing our planet's resources, while constructing the trappings of utility and comfort. And we now stand at the verge of manipulating life itself, potentially altering the genetic makeup of human beings. The physicist unleashes the forces of nature; the biologist experiments with the structure of genes; the psychologist influences behavior with drugs. We are, in fact, forcing a change in the way things change.

The emergence of technologically intelligent life, on Earth and perhaps elsewhere, heralds a whole new era, a Life Era. Why? Because technology, for all its pitfalls, enables life to begin to control matter, much as matter evolved to control radiative energy more than ten billion years ago. As such, matter is now losing its total dominance, at least at those isolated residences of technical competence. This change, from matter-dominance to life-dominance, I claim is the second of two preeminent events in the history of the Universe.

A SENSE OF GLOBAL CITIZENRY

Humanity now stands on an astronomically significant threshold. We have come nearly full cycle. With that remarkable cluster of star-stuff embodied in the human brain, we have become smart enough to reflect back upon the material contents that gave life to us. Life now contemplates life. It contemplates matter. It probes our origin and our destiny. It explores the planetary system we call home. It searches for extraterrestrial life. It quests for new knowledge. But (and oh, this is a big but) shall we survive beyond the dawn of the Life Era? Is there some tool, institution, or attitude to help guide us along the way?

A central point of my essay, indeed an integral part of my personal credo, happens to be the most important implication for the Life Era. It is this: As the dominant species on planet Earth, we must now develop (evolve, if you will, and quickly, too) a global culture. We need to identify and embrace a form of planetary ethics that will guide our attitude and behavior toward what is best for *all* humankind. In short, humans must begin to acknowledge that we are first and foremost

citizens of a planet, only secondarily members of nationally sovereign countries with ever-changing boundaries. It is essential that we broaden our outlook in all respects.

Ethics. My dictionary asserts, among other definitions, that ethics means "conduct recognized in respect to a particular class of human actions or a particular group, culture, etc." Formerly the nearly exclusive purview of philosophy and religion, a viable ethic for today's world is in my view no longer provided by either of these venerable institutions. Lest I be misunderstood, in the next few paragraphs I shall attempt to clarify my criticisms of philosophy and religion *as a source of modern ethics*. And lest someone think my panacea is science, I shall also include science in my brief polemic, for it too, alone, will not likely provide the ethics I feel we need to seek.

Recognize that my concern is worldly, earthly. Whereas ethical values have, for the most part, been historically limited in scope (like unquestioned loyalty to some tribe) or even regionally widespread and more sophisticated (like those introduced into human affairs by Christ), today's set of ethics, like the global problems they must check, need to be of a more planetary, even universal, nature. We must redefine ethics to denote "conduct *collectively* recognized with respect to *all* classes of human actions comprising our *global* culture" (my amended definition), and we must strive to make those ethics a practical reality by simultaneously casting them both broadly enough to apply to *Homo sapiens in toto* and flexibly enough to incorporate the process of change itself. Appropriately, the heart of the required ethics is change and adaptability, not a set of rigid, immutable rules.

At the risk of alienating a number of good friends, consider philosophy for a moment. Once the symbol and guardian of ethics in human society, philosophy has in my view forfeited the influential position it held throughout much of human endeavor. Mostly dated, abstract, anthropocentric, and astonishingly specialized, traditional philosophy has seemingly lost its compass in providing aims and objectives for human society, which in our day and age is both multinational and technological. Regrettably, the great synthesizer is virtually extinct, the legacy and philosophy *of approach* left by Socrates, Plato, and Aristotle, among others, rather thoroughly squandered. Even if we could look to philosophy for worldly guidance, which of the many competing systems of thought should we espouse to the exclusion of all others—rationalism or spiritualism, existentialism or *élan vital*, or even a revival of essentialism, among legions of other philosophies proposed throughout history? In a related vein, which politico-economic doctrine might be most compatible with a global ethics—capitalism, communism, or perhaps a return to theocratic rule, likewise among numerous governmental systems?

As for traditional religion, I deplore its fragmentation. Though we surely now live in a pluralistic society, what are we to make of the fact that our civilization is ministered to by some ten thousand different faiths, each with its own set of beliefs, dogmas, and often insistence that theirs is the "one true faith." How can the institution of religion, given its surprising lack of worldly cohesiveness, guide today's society toward what will surely need to be a coherent framework of understanding for the good of all peoples? While I welcome diversity and pluralism among humanity, how can we possibly base a planetary outlook regarding any principle, let alone one as subtle as ethics, on even a major theology, whether Buddhism, Catholicism, Hinduism, Islam, Judaism, Protestantism, or Unitarianism? As with the dilemmas just expressed regarding choices of philosophical and ideological systems, I perceive no way to decide which set of beliefs could realistically become the effectively official global religion without inviting active hostility among the thousands of competing faiths not so chosen. Note that I am not claiming such a choice to be difficult, rather that it is unproductive, given religious proclivity to grant dogma precedent over reason. Who among today's ecclesiastics takes the larger view, addressing the present and future and not just the past, while advocating unification that might provide a holistic sense of global well-being? Who among them speaks for planet Earth, as materialistic as that may sound?

Nor will science alone (and even less likely in conjunction with its practical by-product, technology) provide the kind of ethics required to attain the Life Era. Here I mean broader *societal* ethics, not the highly regarded and remarkable scientific ethics that keep fraudulent science to an absolute minimum. Despite the moral concerns of some scientists and professional societies (witness the 1975 Asilomar conference of biologists questioning the proprieties of genetic engineering, and the moral distress expressed by many physicists associated with the development of the atomic bomb) the great majority of my colleagues are unaware, or at most mindful but inclined toward benign neglect, of the socioethical implications of their work. (Even at Asilomar, the debate concerned public health consequences, not the larger ethical and moral issues, of research in recombinant DNA technology.) Though we seldom admit it, our excessive specialization makes us astonishingly myopic, blinding us to the wider cultural impact of our research—at least while working at the height of our careers. Later in life and often in retirement, when scientists are usually dismissed as "no longer active" or even potentially senile, many of science's most eminent scholars begin examining the broader consequences of their work. Regrettably, often only when their influence has eroded by a sort of career entropy do they discover that some of their earlier research carried global implications. Is it possible that the duties and respon-

sibilities, normally coupled one-for-one in the legal profession with every right and privilege, have not comparably grown in the last many decades with the rapid expansion in basic scientific research? Should we not awaken our attention to a formal code of socioethics among scientists as a sort of *quid pro quo* for the right to freedom of research?

All this is by way of encapsulating how in my view neither philosophy nor religion alone, alas not science alone either, is likely able to generate a compelling set of global ethics required to aid humankind at our current turning point. Granted, each of these institutions might think they do, but my claim is that none of them individually can be counted on to provide an ethical standard needed for the human species to endure rapid, global, often self-induced changes in our politico-economic and especially technological environments. The twentieth-century philosophical writer, Will Durant, well articulated our growing predicament: "We suffocate with uncoordinated facts; our minds are overwhelmed with sciences breeding and multiplying into specialistic chaos for want of synthetic thought and a unifying philosophy."

EVOLUTION AS A SOURCE OF ETHICS

If not to one of these established institutions, then where do we turn for guidance, for survivability, at least for a sense of hope? The answer in my view is that we should look to an amalgam of these three, provided we can identify a common denominator or underlying unity to which each of these three institutions can subscribe. Fortunately, we do know of a unifying pattern pervading all; that common basis is evolution. Affecting everything in the Universe, from galaxies to snowflakes, from stars and planets to every aspect of life itself, evolution—developmental change—pertains to all objects, societies, civilizations, and institutions. In particular, the concept of evolution, invented by philosophy and now fully embraced by science, is acceptable to all but the most fundamentalist religions. Its broad approval is why an appreciation and understanding of evolution in its most awesome sense—cosmic evolution, a scientific philosophy capable of applying the tools of technology to the time-honored questions first posed by philosophers and theologians—can provide a map for the future of humanity.

For those who would promptly balk at this proposed synthesis, seeking instead to preserve the *status quo* by resorting to traditional institutions, let me say this. In my mind, all philosophy and religion seek a static truth: a one true dogma on which everyone can converge. But modern science has now (re)discovered such a fixed reality and bolstered it with observational evidence; it is the process of change itself. In an intriguing apposition of terms befitting the age-old ideas of

Heraclitus, change has a genuinely static presence in the Universe. What is more, in the new non-equilibrium thermodynamics, change is the root of all organized stability. Once we have adjusted our thinking to accept this permanence of change, we can proceed, if need be, to change that change in ways that lead to beneficial evolution rather than devolution, entropy, and extinction. Of great import, the process of change and the “big thinking” that cosmic evolution represents can form the essence of an intellectual vehicle needed to develop, indeed to evolve, a worldly set of ethics.

As noted earlier, the seventh great construction phase of the Universe I often label *future evolution*. I now tell my students that if our species is to survive to enjoy a future, then we must make synonymous the words *future* and *ethical*, thus terming our next grand evolutionary epoch, *ethical evolution*.

The Universe does conform, not to a grand design, but to the chancy dictates of evolution, including, presumably, the developmental advances required for technologically intelligent life forms to survive. After all, since we have recently become agents of change on Earth, we must now begin playing an *active* role in the process of evolution. I maintain that that active role must begin with a collectively recognized set of ethics or principles suited to the preservation of all humankind. Furthermore, like the evolutionary changes that, in turn, originated and developed particles, galaxies, stars, planets, biochemicals, lives, and cultures, transition toward the next step of globally conscious life forms is a universal phenomenon. All technological beings, on any planet, must evolve a planetary ethic, lest they be unprepared to endure the by-products of technoculture. In fact, implicit within our cosmic evolutionary paradigm is a transcendence of the Darwinian principle of natural selection, a loftier standard that I call the principle of cosmic selection: Those technological civilizations (of any type on any planet) that recognize the need for, develop in time, and fully embrace a global (even a galactic, and then a cosmic) ethics will survive, and those that do not will not.

Of course the possibility always exists that no species on any planet, ourselves included, will be sufficiently intelligent and especially wise to take the next evolutionary leap forward. While I prefer to think otherwise, the Universe could conceivably be regulated by a natural (or even supernatural) “cosmic principle of self-destruction” dictating that all development abruptly stops roughly within a few decades to a century beyond the time when each civilization begins encountering world-wide problems; if so, then we on Earth have come within this principle’s purview only during roughly the last decade. More than just a statement of ordinary biological extinction (for here destruction is self-

induced), such a principle could naturally derive from a drive toward complexity that effectively runs out of control. The rate of change might itself change so rapidly that not even technologically intelligent life could keep pace with its accelerating onslaught of global troubles, the result being that eventually all civilizations commit the ultimate devolutionary change: termination. Less of an anthropocentric statement than it initially might seem, this supposed principle of destruction would ostensibly apply to every planet, thus alleging that no one progresses much beyond our level of expertise. According to those who subscribe to it (strangely enough, mostly biologists, aside from the habitually negative sociologists), the Universe remains matter dominated everywhere and forevermore, making no appreciable advance beyond the dawn of the Life Era.

By contrast, there are those (myself included) who prefer to opine that some civilizations (though not necessarily ours on Earth) could become smart enough quickly enough to welcome the needed ethics sufficiently to persist beyond our current level of technological expertise. Though I know nothing of the sociology of galactic aliens, my thesis here is that the way *for us* to wisen rapidly is to adopt cosmic evolution as the guiding paradigm and *nouveau* scientific philosophy for our time. Mine is a positive view, a synthesizing posture, and, I judge, a realistic attitude despite the onslaught of apocalyptic issues now confronting us on Earth—a vision that decidedly rejects the cosmic principle of self-destruction just noted, to be sure one that offers a more confident, enduring, or at least optimistic prognosis. To employ cosmic evolution as an intellectual as well as practical guide toward the Life Era is to think in dynamic rather than static terms, to forge a link between natural science and human history, to realize the evolutionary roots of human values, to renew a sense of hope.

COSMIC EVOLUTION AS RELIGION, CHANGE AS GOD

The subject of cosmic evolution is worthy of an ultimate concern, even an ultimate commitment. More than that, cosmic evolution is my credo, my religion. I say this not to muddy the waters between religion and science, but because cosmic evolution is the personal *weltanschauung* to which I am bound religiously, ultimately. Furthermore, much like traditional religions, cosmic evolution gives our lives meaning and significance, a *raison d'être*—in my view, to act as an animated conduit for the Universe's self-reflection.

In many ways akin to Paul Tillich's general definition of religion rooted in awe, majesty, and an "experience of the 'ultimate' in the double sense of that which is the abyss and that which is the ground of man's being," cosmic evolution grants for us perspective from which

we can recognize not only that the universal process of change pervades nature but also that we are, quite literally, children of the Universe. Awesome, majestic, ultimate, indeed.

And if God is the name of that which concerns humans ultimately, then the essence of cosmic evolution—developmental change—must be my God. A pantheistic view to be sure, but one that more than simply equates God and Nature. My God is a specific process of nature, an omnipresence that effectively inundates all things material. Indeed, as noted earlier, the process of change is truly the hallmark in the origin, the destiny, and even the maintenance of galaxies, stars, planets, and life forms. Taking the argument to its logical extreme, we can identify the most dramatic and ongoing change—the expansion of the Universe—with the Prime Mover. Befitting any *scientific* philosophy and in keeping with the notion that any genuinely ultimate concern must represent concrete experiences, the process of change (including its Prime Mover) can be both observationally studied and mathematically modeled. This is my ultimate concern, my life's work.

SUMMARY

I suggest that cosmic evolution is a powerful synthesis to use as perspective—a grand ethos of potentially unprecedented intellectual magnitude—while approaching an uncertain future. Looking backward, we sense that its central feature, the time-honored concept of change, can account for the appearance of matter from the primal energy of the Universe, and in turn for the emergence of life from that matter. Change further seems capable of describing the act of creation itself, thus scientifically accounting for the origin of all energy at the alpha-point of space and time.

But are we Earthlings to survive to learn more about ourselves, our planet, our Universe? Looking forward, shall we achieve some astronomical destiny? Just how wise, quite aside from sheer intelligence, are we? Put bluntly and not insignificantly: From the study of cosmic evolution may well emerge a sense of “big thinking” and with it the global ethics and planetary citizenship needed if our species is to have a future. In the words of Søren Kierkegaard, “Life can only be understood backwards, but it must be lived forwards.” Tritely stated though no less true, our future will likely be a measure of our current wisdom.