*Every week, "Outposts" examines cutting-edge ideas sparking debate on campuses and in labs around the country. This week, Eugene F. Mallove examines the theory that intelligent life may reshape the universe and affect its ultimate fate. Mallove, an astronautical engineer, is a science writer and broadcaster with the Voice of America in Washington.*

## COSMOLOGY

# Do We Control the Universe's Fate?

By Eugene F. Mallove

WITH SPECTACULAR leaps of imagination, cosmologists are studying how we humans might some day transform the universe, and perhaps even save it and our own species' precious hides from oblivion.

In fact, the frontier questions in cosmology today include:

- On the grandest scales of time and space, does life have an important role to play in the evolution of the universe, or are we merely along for the ride?
- Does intelligent life—human or extraterrestrial—have a prayer of a chance to preserve itself as the universe runs down?
- What part of the universe's evolution would we have any interest in changing, if we could somehow muster the power to do so?

Physicist Freeman Dyson in 1979 was among the first to answer. "It is impossible to calculate in detail the long-range future of the universe without including the effects of life and intelligence," he asserted.

Life arguably already has begun to transform the cosmos and it arose barely four billion years ago, according to best evidence. Earth's biosphere—that thin shell of air, soil and ocean—already appears to be fully controlled by life. The reason the planet possesses an oxygenous atmosphere is the exhalations of countless plants and microorganisms. Life has visibly reworked the surface of the world. By some scientific accounts, life appears to be acting on a global scale as a single giant organism, regulating internal temperatures and chemical concentrations much as do individual beings. So on one world we have a definite analogy to what might happen over trillions of years on an interstellar or even intergalactic scale: life altering its environment far beyond the locale of individuals.

Humans, fresh from conquering the air with wings less than a century ago, now lay tentative claim to much of the solar system. If our civilization does not self-destruct, or turn dangerously inward, it seems that nothing will prevent the colonization of the Sun's planets, space, moons and asteroids.

Within several hundred years—perhaps far sooner—people may live on dozens of distant worlds, some of which may be changed forever by human design. Realistic plans are already being made to "terraform" Mars—to remake it in the image of Earth by gradually changing its climate and atmosphere. Even hellish Venus may submit to human desires for clement worlds. Among theoreticians, astroengineering on the scale of a whole planet has been discussed for so long it is almost passe.

Freeman Dyson suggested years ago that a civilization might actually disassemble the planets of its childhood and construct a spherical network of orbiting structures completely enclosing its star. Within this "Dyson sphere," the interplanetary civilization could capture nearly the total energy output of its sun. Dyson even proposed that astronomers seek evidence of extraterrestrial civilizations from the infrared radiation that would necessarily be emitted by such stellar envelopes.

Unfortunately, even our Sun won't shine benignly forever. It has been fusing its hydrogen into helium for nearly five billion years, providing energy for earthly life for much of that time. But about five billion years hence, with its fuel reserves dwindling, the sun will enter a so-called "red giant" phase. Its bloated body will extend beyond the orbit of Earth. No matter how good our engineering, that probably will be the high-water mark for the intelligence remaining in the solar system. If by then it has not already done so, life may have to abandon its now malevolent home.

### Reorganizing the Universe

It is impossible to project what our civilization might be like billions of years in the future. In fact, at current rates of change, life may be altered more between now and only 1,000 years hence than it was altered in the 5,000-year span between ancient Egypt and modern civilization.

But it is distinctly possible that we will deliberately engineer biological changes in humans and achieve physical symbiosis with compact forms of electronic artificial intelligence. These trends are already under way—increasing reliance on computers and biotechnology—and perhaps one day will culminate in a form of biological immortality or the abandonment of biology altogether. Perhaps our psyches will eventually comfortably inhabit non-biological "machines." If the thought is discomfiting, try to imagine these progeny as loving "children" who are as much (and more) products of ourselves as our own genetically endowed offspring.

Biological and cultural changes are arguably more difficult to forsee than the physical expansion of civilization into interstellar space. The distances between individual stars are humbling—typically 250,000 times the 93 million miles from Earth to the Sun. But there are

many ways we know already to cross the gulf—even constrained by the seeming impassable barrier of the speed of light.

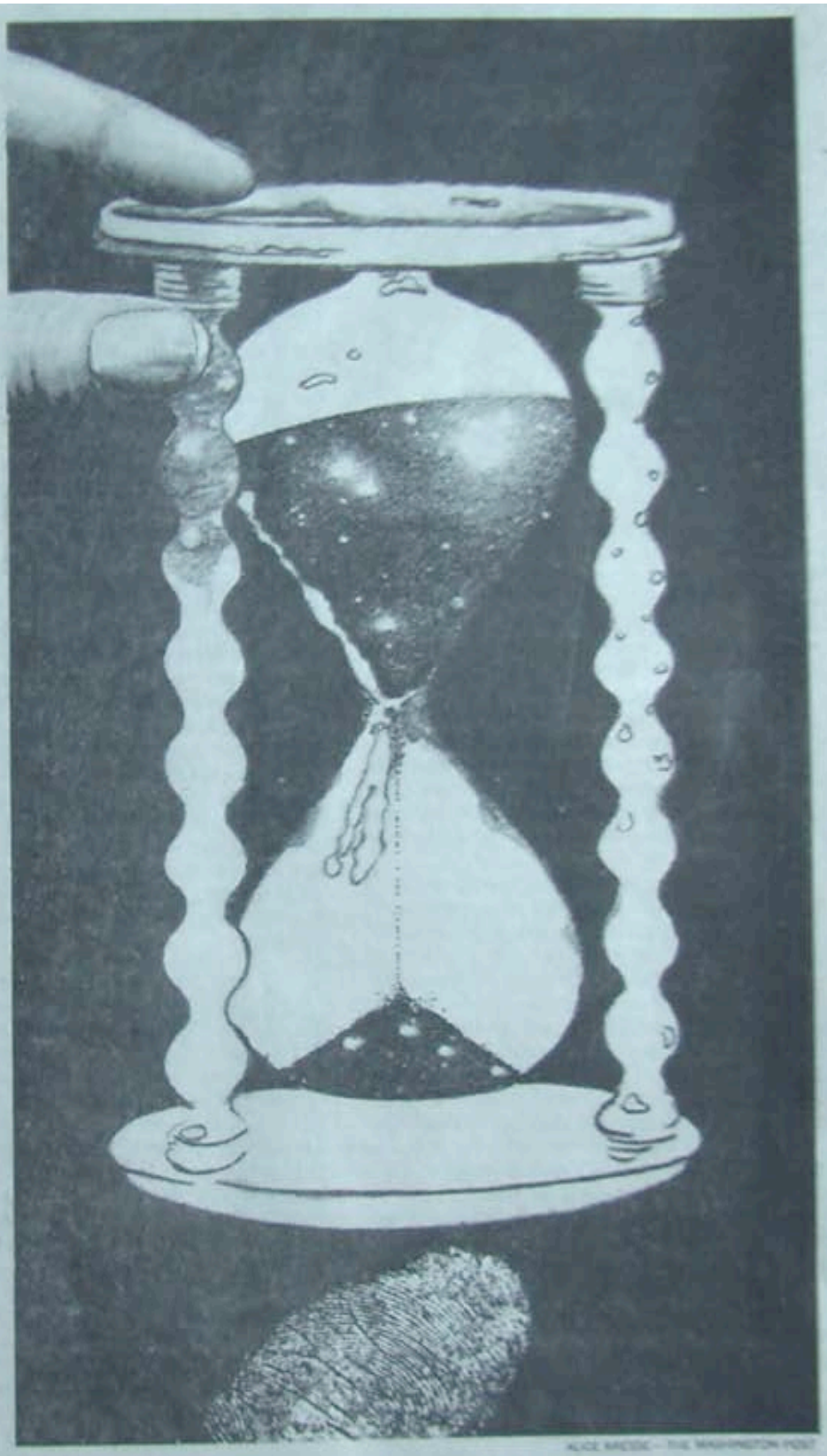
Engineers and physicists have worked for years planning the technology of interstellar travel. Probably in the next century—and certainly within 200 years—robotic probes will make journeys to the nearest stars. These craft may make the trip only in decades, rather than the millenia our present slow boats would consume. Peopled missions to the stars will be far more costly, but when sufficient motivation has developed (perhaps combined with extended lifespan), human beings will venture to worlds around other stars.

This leads to a vision of our own civilization expanding in a wave of colonization—each stellar outpost giving rise to more remote ones—and by geometric progression eventually encompassing billions of solar systems in the Milky Way galaxy. The transformation from an interplanetary to an interstellar civilization has been calculated to be possible in far less than a billion years—a mere eye-blink in the perhaps trillions of years of cosmic time yet to pass.

This supposition has led to heated debates about why we don't see extraterrestrials crawling all over the place. The logic is that if we could ignite waves of interstellar colonization, presumably they could, too. One answer to this argument is that we may simply not be aware of the way other life forms are altering the universe. It's possible that we simply aren't aware yet that we lie in the midst of a galactic communications net that trafficks in artifacts as well as invisible electromagnetic messages. When we gaze at the heavens, we don't see any remarkable patterns of stars that spell out "Eat at Joe's," nor the slightest sign that extraterrestrials are zipping around remaking the cosmos for their own needs.

But that doesn't mean that stupendous reorganization of the universe by life is not under way. Dreaming wildly, we could imagine subtle artificial changes already taking place—ones we simply haven't recognized. Or it may still be the springtime of the galaxy and Earth is among only a handful of civilizations just beginning to realize their potential to change the course of cosmic history.

**Preserving Consciousness**



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come completely etherialized, losing its close-knit organism, becoming masses of atoms in space communicating by radiation, and ultimately perhaps resolving itself entirely into light."

Nineteenth-century physicists were obsessed with the idea that the universe would ultimately suffer a "heat death" as all matter grad-

change, and thus life is impossible. Instead of everything just "melting" into a soup of constant temperature as in the 19th-century picture, life processes of the far distant future would be perpetually in danger of freezing to a grinding halt.

Frautschi suggests an out: "A sufficiently resourceful intelligence inhabiting a critical universe learns

cosmic history.

### Preserving Consciousness

What would be the course of the universe if we and other sentient life, acting in a spirit of cosmic environmentalism, did nothing to upset natural balances? The universe would continue for at least tens of billions of years its spectacular expansion that began about 15 billion years ago with the "Big Bang." After that, the future gets more murky. But groups of physicists have already begun calculating the ominous events from here to eternity—assuming we and "others" do nothing to change them.

The numbers of years to these remote eras are so unimaginable that one can only begin to visualize them as multiples of the present age of the universe. Thus, 15 billion years becomes one "unit" in this chronology.

Ten thousand units into the future (10,000 times the current age of the universe), all the stars will have spent their nuclear fuels and will be mere glowing cinders.

By 10 million units, all planets will have been torn from their stars by the gravitational forces in chance disruptive close encounters with other stars.

By 100 million units, near misses between dead stars will have kicked or "evaporated" all of them out of galaxies, leaving behind a voracious black hole in each galaxy to devour the little remaining matter.

By 100 billion units, if current theories of matter are correct, all the protons in all the stars will have decayed to radiation and the subnuclear particles—electrons and positrons.

In the final act at one-followed-by-90-zero units, the universe's remaining black holes may have all evaporated and the cosmos may then consist almost entirely of radiation.

Yet such a continually expanding universe delights the imagineers of the distant future. The cosmologists' equations forsee an era when intelligent life has long since transformed itself to ethereal forms—perhaps gossamer collections of nuclear particles tenuously linked together over vast distances. The object of such evanescent life: a fantastic struggle to preserve memories and consciousness in a cosmos growing colder by the eon as supplies of usable energy dwindle.

Physicists do not, of course, presume to know the details of how such ghostly beings would be constructed. But they employ the esoteric equations of thermodynamics, information theory and general relativity to establish whether information—the essence of life—could theoretically exist at all under scarcely imaginable physical conditions.

A hint of this destiny appeared in a 1929 essay, "The World, The Flesh and the Devil," by British physical chemist J.D. Bernal who wrote, "Consciousness itself may vanish in a humanity that has become obsessed with the idea that the universe would ultimately suffer a "heat death" as all matter gradually approached an equilibrium temperature and maximum disorder or entropy ensued. With everything at the same temperature, no useful energy would be available to do work—no thoughts could exist in such a world. This was thought to be the inexorable toll of the Second Law of Thermodynamics.

But the expanding universe and modern gravitational theory have now exorcised the "heat death" demon somewhat. Physicists no longer believe that the cosmos will "run down" in exactly the way their forebears imagined. They say that though entropy will constantly increase, it will not increase as fast as the universe will expand, thus theoretically keeping open the possibility for organization to continue.

Physicist Steven Frautschi, who extended Dyson's work, wrote in 1982, "We have thus come to a conclusion which stands the 19th-century model on its head. Far from approaching equilibrium, the expanding universe . . . falls further and further behind achieving equilibrium. This gives ample scope for interesting nonequilibrium structures (e.g. life) to develop out of the initial chaos, as has occurred in nature."

Ironically, the problem theoreticians now see is not that there may be maximum universal disorder, but that the amount of it will approach a low, but constant limit. It would be changeless. Yet life and growth *is* change. In a world with constant entropy, there is no Frautschi suggests an out: A sufficiently resourceful intelligence inhabiting a critical universe learns how to move black holes, bringing them together from widely separated locations and merging them to increase entropy." Life could then use these merged black holes as a power source.

### Eternal Ethereal Life?

Dyson theorized that ethereal life could live eternally by husbanding energy resources and hibernating for extended periods between the ages of active contemplation that will be the major function of life in that penultimate state. He concluded sanguinely that "no matter how far we go into the future, there will always be new things happening, new information coming in, new worlds to explore, a constantly expanding domain of life, consciousness and memory.

"I have found a universe growing without limit in richness and complexity, a universe of life surviving forever and making itself known to its neighbors across unimaginable gulfs of space and time."

For entities not accustomed to worrying about events much further removed than a few years, or at most a decade, speculating on the happy or sorry fate of the universe billions of years from now may seem an unlikely exercise. Yet faced with a cosmos that seems to have every appearance of expanding forever, the idea that intelligent life could play a major role in shaping it is the most sobering thought imaginable.

# Intelligence Unbound

IN THEIR RECENT book, "The Anthropic Cosmological Principle," which is packed with formulas, astrophysicists Frank Tipler and Barrow end with a conclusion of truly messianic proportions: ". . . Life will have gained control of *all* matter and forces not only in a single universe, but in all universes whose existence is logically possible.

"Life will have spread into *all* spatial regions in all universes which could logically exist, and would have stored an infinite amount of information, including *all* bits of knowledge which it is logically possible to know. And this is the end."

But not quite, because in a footnote they add that a modern theologian might agree that life at this point would then be "omnipotent, omnipresent and omniscient."

It is impossible to avoid the impression that theology and cosmology are becoming hopelessly entangled. A peculiar theo-cosmology seems to be emerging without rigid doctrines. And physicist Freeman Dyson set forth its fundamental tenet: "If our analysis of the long-range future leads us to raise questions related to the ultimate meaning and purpose of life, then let us examine these questions boldly and without embarrassment."

Open questions for an open universe.

—Eugene Mallove