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The Preservation of Natural Value in the Solar System

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Set as a shining jewel in the dark abysses of space, Earth is a unique treasure, exuberant with life. Millions of species have evolved, increasing in variety and complexity over billions of years. By contrast, the space environment seems hostile, cold, empty. Earth is home, a fertile oasis; that is the good news. The bad news is that Earth is lost out there in the stars. A solar system, a galaxy, even a star, is mostly nothing, empty space; and where there is something, it is sterile—frozen or scorched, swirls of gases or inert rockpiles. But an ecosystem, especially one with persons, an Earth, this is something rich and significant, an intricate web of instrumental and intrinsic values.

Earthlings live neither at the range of the infinitely small nor of the infinitely large; but humans may well live at the range of the infinitely complex. In a typical handful of humus, which may have ten billion organisms in it, there is a richness of structure, a volume of information (trillions of "bits") enormously advanced over anything elsewhere in the solar system, or even, so far as we know, in myriads of galaxies. The human being is the most sophisticated of evolutionary and ecological products. In our seventy kilograms of protoplasm, in our single kilogram or so of brain, there may be more operational organization than in the whole of the Andromeda Galaxy. The number of possible associations among the ten billion neurons of a human brain, and the number of thoughts that can result from this, may exceed the number of atoms in the universe.

Out there, trillions of atoms spin round and yield nothing more than aggregated whirls of flaming gas, clouds of dust, raw energy, rotating and revolving chunks of brute matter. But here trillions of atoms spin in richly informed ways to yield life and mind, with sentience and cultured experiences. Space is barren, perhaps not entirely but almost so, seen in contrast with the fertility of Mother Earth. Michael Collins, a veteran astronaut, concludes, "The more we see of other planets, the better this one looks."[1]

Such an account—treasure-here/emptiness-there—is relatively true. But is it absolutely all that needs to be said? The last two decades have been productive for space exploration; we have visited and probed other worlds, mapped planets and moons, increased our knowledge by an order of magnitude. The same two decades have also been notable for the emergence of environmental ethics, with its rethinking of the philosophy of nature, its reformed appreciation of values carried on the ecosystemic Earth. We have increased our sensitivity by an order of magnitude. Now is the time for value explorations in space, for a philosophy of the solar environment to complement that of the biospheric environment. What follows is an ethical probe into the solar-planetary system.

I. *Accidental Nature: Earth as an Astronomical Accident*

A moment's reflection introduces anomalies into this value-at-home/waste-elsewhere perspective, Except for activity dependent on radioactivity, Earth is solar-powered. The energy with which I write and that with which you read was supplied by a nuclear reactor 149,600,000 kilometers away. The ecosystem is the Sun/ Earth, in some sense heliocentric even though the complexity is mostly earthbound. The solar sphere is as vital as the atmosphere. Once we start considerations like this, there is almost no stopping of them.

The Sun/Star is the right size and age. About its central star, Earth must (a physical requirement, if there is to be life) occupy an orbit that permits water to form and liquid water to circulate over most of its surface. Earth must be big enough to retain an atmosphere, small enough that the atmosphere can evolve from a reducing to an oxidizing one, with the proper gases to provide an insulating effect. Earth's tipped axis produces the diversity of seasons, and there is enough differential heating to drive favorable hydrologic and meteorological cycles, making weather and climate. Earth has a moon, which produces the tides and creates the crucial intertidal zone, where life later moves from sea to land. Earth has a thin, condensed crust surrounding an incandescent globe, a living skin over hot rock. There is enough radioactive heat buried in the core to keep the crust active, rechurning environments, while degassing an atmosphere "blessed" with hydrogen, carbon, nitrogen, and oxygen compounds, all becoming ingredients in a thin hot soup from which life can evolve.

All this makes the right setup for life. Recalling that an ecosystem requires both energy and materials, we may first say that the materials are already here, only recycled, while the solar energy has to be resupplied daily. But the materials were not always here, and their history takes us back to the formation of Earth and solar system, and then back further and out of the solar system. The Earth is linked up to the solar system and beyond. In one way, we Earthlings have powers that exceed anything else found in the solar system; but in another way that system has powers we do not, since it generated us. We are first in complexity, last to arrive.

Alas, however, there is no scientific theory how, much less why, all these puzzle pieces should fall together so fortunately. Space exploration has not produced a scrap of progress on this issue, not even a promise of any lawlike, systemic headings in the solar system. So, fearing cognitive dissonance, the official doctrine is to affirm positively (lest the really negative character of the claim be heard) that the fortunate planetary setup is due to "astronomical accidents."[2] Those who speak of Earth as being an "accident," like those who say that life is an accident, are often not clear what they mean. "Accident" usually has two, conflated layers.

(1) The set of resulting characteristics, which on Earth are highly valued, result in significant part from the impingement of otherwise unrelated causal lines. That is, the productive factors, while fully causal at least in a statistico-deterministic sense, were tending nowhere; this is *relative randomness.* All events have followed small- or middle-scale causal laws; these causal laws, while everywhere operative, have no systemic unity, no governing integration. Causal events in their complicated interactions are a big mess, and there are no large-scale laws that determine that the nine planets will be

placed thus and so, with the third one at just the proper distance to make it a habitat for life. There is nothing holistic about the systemic organization. The necessities and beauties of celestial mechanics notwithstanding, the system is a chaotic jumble,

Such relative randomness is compatible with unbroken causation, but not with systemic organization at cosmic or solarplanetary levels. Events are causally determined, but accidental in that there is no principle producing high-order result, accidental in not merely a teleological sense, but accidental in any systemic sense. The unbroken causal lines are a jumble, not those of a system with tendencies to produce anything, certainly not tendencies to produce life or mind. Adapting the somewhat outmoded vocabulary of Aristotle, there are entirely sufficient efficient causes, but these neither necessitate nor make probable the operation of any formal causes. The system has no formative tendencies.

(2) There is a further kind of randomness that some times also enters astronomy. The set of highly valued characteristics, though they result from many interjumbling causal lines, may have, further, some indeterminate points. The set of antecedent efficient causes were not sufficient for the set of resulting characteristics Earth has. There is some *absolute randomness* in Earth's past history. The various factors that resulted in the characteristics of Mercury, Venus, Mars, Jupiter, Saturn, Titan, Mimas, Ariel, and so on include some genuine dice throwing. The system is to some extent open, not fully deterministic.

This absolute kind of randomness first entered physics at the microscopic level in quantum physics; and many physicists think still that there are no macroscopic effects at everyday levels, much less astronomical effects at solar-planetary levels. All indeterminacies wash out in the averages, overwhelmed by the statistical odds, and big-scale events are fully statistico-deterministic. But others are not so sure. Thermodynamics has yielded some surprises in systems previously thought to be deterministic. Climates, once assumed to be fully causal, may be partially open systems. What goes on in so-called "naked singularities" and "black holes" is supposed by some to warp or destroy causal laws and constants, perhaps with some absolute randomness in result. Cosmologists even take the expanding universe back in time and shrink it in size until, in what they call the Planck Era, quantum indeterminacies become relevant in the subsequent placement of galaxies. In the oscillating universe—big bang, big squeeze, big bang squeeze—in each new epoch "the universe is squeezed through a knothole."[3] and its features, causal laws, constants are destroyed and reemerge with some characteristics set by absolute randomness. One hardly knows what to make of such speculations. Randomness of either kind, relative or absolute, is consistent with the official doctrine about what happens on Earth, after it is formed, during the evolutionary development. That course too has antecedents without headings; life's outcomes are matters of mutation, genetic drift, biological accidents, "chance riches."[4] The spectacular story that manages to happen first in chemical evolution and later in biological evolution is perfused with relative and absolute randomness. So why should anyone think the planetary evolution any less so? One way to confirm this is to see how fortunate Earth is by comparison with the unlucky planets. Planets come in great variety, but there are no interesting achievements on any others. They are unsuitable for life; they will be almost impossible places to visit. They are suspended in permanent deep freeze, or they boil in chaotic heat. Earth is paradise; they are hells.

This means for value theory that humans cannot value the causes that lie behind Earth as positively productive forces, for they were not. Earth is where and what it is by luck, causal forces notwithstanding. The most that humans can say, after we arrive and reflect about our circumstances, is that these lucky concatenations of intersecting causal lines, once dissociated and later scrambled, mixed also with absolute randomness, if such there is, are instrumentally valuable retrospectively. They did in fact happen to result in our being here, and one can certainly value good luck. But anyone is deceived who thinks he or she is valuing more than chance riches. The astronomical forces are not even valuable instrumentally in any systemic sense, for there is no coherent system, much less are such forces intrinsically valuable in themselves. Places where these kinetic forces have produced something unearthly are out of luck. Jupiter and Pluto, or the minor planet Chiron, are not even instrumentally valuable. None of the non-Earth places, unless they once stood in the causal chains that produced Earth or yet stand in support of Earth, are *of value.* They just *are*—brute matter or raw energy; they are only matter-in-motion; so never mind!

It seems at this point that a positive environmental ethic is also out of luck. Ecology, etymologically, is a logic of one's home, and our home is locally Earth. Regionally, our home is the solar system; cosmically, it is galaxies and beyond; and an environmental ethic might not seem finished until it has an account of the space environment. But no comprehensive account can be given; the solargalactic environment is, at bottom, a randomness, relative or absolute, because of the jumbled causal lines and mixed indeterminacies. The most that can be asked is whether and how we Earthlings, who have so resourcefully used Earth, can someday make *resources* of these non-Earth places, mining the Moon, doing experiments on Venus, taking a vacation touring Saturn —a secondary environmental ethic. But no primary environmental ethic is possible, no account of the productive *sources.* The question is whether this astronomical world can *belong to us;* there is no question how we *belong to it,* and no question whether it *belongs by itself*

2. Anthropic Nature: A Fine-Tuned Universe

The route that space explorers have to follow, leaving *terra firma,* is to enlarge the circle of investigation little by little, exploring first the Moon, then nearby planets, then probing more distant ones. Even astronomers who stay at home and look outward have to push farther and farther, starting in our own galaxy, moving to galaxies beyond, and thence to the edges of the universe. This has been done sufficiently to permit a "space axiologist," puzzled about the astronomical accidents that put Sun, Earth, Saturn in place, to begin at the beginning. Cosmologists have already been doing these explorations, and I plan next to quit nearby value exploration and send a probe back to the beginning, down to the foundations. In the strange curvatures of space-time, which can bend logic as well, the longest way round can be the shortest way home.

We can put our valuational probe on board some experimental probes already underway investigating the formative astrophysical forces. These inquiries have yielded an impressive result with a rather unfortunate name—the *anthropic principle.* We cannot do experiments revising the universe, but we can do thought experiments to see what another one would be like. Contrary to the picture of accidental nature just sketched, the result is that the universe is mysteriously right for producing life and mind, demonstrably on Earth and perhaps just as well elsewhere, a result that would better be said to yield *biogenic* and *psychogenic* principles.

The universe is twenty billion light years across, twenty billion years old, staggeringly lavish in its size and age; and within it matter is very rarefied. Matter also condenses into complex formations, the most impressive of which are life and mind. But the rarity of any biological environment supports the previous picture that nature on the whole is a ridiculous swirl and empty waste. Together with our neighboring life forms on Earth, humans are puny and transitory phenomena having no essential relationships to these vast, dumb processes that constitute all but the tiniest fraction of nature. We are epiphenomenal; we are astronomical accidents.

Next, however, let us change this picture around, using some *if-thens. If* we remove the stars, *then* most of the story fails. In the astronomical world—galaxies, stars, space—nature mostly exists at the low structural ranges of micronature—as particles, electromagnetic radiation, electrons, protons, hydrogen. Yet in the stars nature energetically builds and steadily aggregates. The stars are the furnaces in which all but the very lightest elements are forged. Without such stellar cultures there can be no later evolution of planets, life, mind. Supernovae explode to disperse their matter throughout space. Earth and its humans are composed of stardust, fossil stardust! The stars cook up the dirt, which later becomes the humus, which later cooks up an ecology with its humans.

Interestingly, the mix of elements in the later stars, despite their enormous heat, is as favorable for the future of life as is the mix of elements on Earth. Indeed, says George Wald, an evolutionary biochemist, " the proportions of the elements in living organisms is much closer to their distribution in later-generation stars than in the planets. . . . The stars are in every way closer to life."[5] So no one with a cosmic view can think that the stars play no part in forming ecosystems. They supply energy and materials for all that comes after.

If we make a substantial reduction in the number of particles in the universe, or in its total size, *then* what would be the consequence?[6] There is not enough material or enough cooking time for thermonuclear combustion, which requires several billion years to build the heavy elements. No universe can provide several billion years of time, according to the theory of general relativity, unless it is several billion light years across. *If* we cut the size of the universe by a huge reduction (from 10^{22} to 10^{11} stars), *then* that much smaller but still galaxy-sized universe might at first seem roomy enough, but it would run through its entire cycle of expansion and recontraction in about one year!

If the universe were not expanding, *then* it would be too hot to support life. Indeed, *if* the expansion had been a little faster or slower (especially since small differences at the start result in big differences later), *then* connections shift so that the universe would already have recollapsed or so that galaxies, stars, and planets could not have formed. The extent and age of the universe are not obviously an outlandish extravagance, if it is to be a habitat for life and mind at its middle ranges. Indeed, this may be the most economical universe in which mind can flower on Earth and perhaps elsewhere—so far as we can cast that question into a testable form and judge it by present physical science.

If the matter of the universe were not so relatively homogeneous as it is, *then* large portions of the universe would be so dense that they would already have undergone gravitational collapse. On the other hand, *if* the distribution of matter were entirely homogeneous, *then* the chunks of matter that make development possible could not assemble. Other portions would be so thin that they could not give birth to galaxies and stars.

Further, many physical constants and processes, both at microphysical and astronomical levels, strikingly fit together to result in what has happened. Change slightly the strengths of any of the four forces that hold the world together (the strong nuclear force, the weak force, electromagnetism, gravitation—forces ranging over forty orders of magnitude) or change various particle masses and charges, and the stars burn too fast or too slowly, or atoms and molecules, including water, carbon, oxygen, do not form or do not remain stable, or other checks, balances, cooperations are interrupted.

B. J. Carr and M. J. Rees, cosmologists, conclude, "The basic features of galaxies, stars, planets and the everyday world are essentially determined by a few microphysical constants and by the effects of gravitation. Many interrelations between different scales that at first sight seem surprising are straightforward consequences of simple physical arguments. But several aspects of our Universe—some of which seem to be prerequisites for the evolution of any form of life—depend rather delicately on apparent 'coincidences' among the physical constants. . . . The Universe must be as big and diffuse as it is to last long enough to give rise to life,"[7]

If one undertakes thought experiments revising the ratios, constants, atomic sizes, and dynamics in the laws that govern these operations, then one runs into similar impossibilities, surprises, and unknowns. When we consider the first few seconds of the big bang, writes Bernard Lovell, an astronomer,". … it is an astonishing reflection that at this critical early moment in the history of the universe, all of the hydrogen would have turned into helium if the force of attraction between protons —that is, the nuclei of the hydrogen atoms—had been only a few percent stronger. In the earliest stages of the expansion of the universe, the primeval condensate would have turned into helium. No galaxies, no stars, no life would have emerged. It would have been a universe forever unknowable by living creatures. A remarkable and intimate relationship between man, the fundamental constants of nature and the initial moments of space and time seems to be an inescapable condition of our existence. ... Human existence is itself entwined with the primeval state of the universe."[8] Concluding a study of energy processes on cosmic scales, Freeman J, Dyson, a physicist, writes, "Nature has been kinder to us than we had any right to expect. As we look out into the universe and identify the many accidents of physics and astronomy that have worked together to our benefit, it almost seems as if the universe must in some sense have known that we were coming."[9]

Fred Hoyle, an astronomer, reports that he was shaken by his own discovery of critical levels involved in the stellar formation of carbon into oxygen. Carbon only just manages to form and then only just avoids complete conversion into oxygen. If one level had varied by a half a percent, the ratio of carbon to oxygen would have shifted so as to make life impossible. "Would you not say to yourself, . . . 'Some supercalculating intellect must have designed the properties of the carbon atom, otherwise the chance of my finding such an atom through the blind forces of nature would be utterly minuscule'? Of course you would. . . . You would conclude that the carbon atom is a fix. ... A common-sense interpretation of the facts suggests that a superintellect has monkeyed with the physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question."[10] "Somebody had to tune it very precisely,"[11] concludes Marek Demianski, a Polish cosmologist and astrophysicist, reflecting over the big bang.

How the various physical processes are "fine-tuned to such stunning accuracy is surely one of the great mysteries of the cosmology," remarks P.C.W. Davies, a theoretical physicist. "Had this exceedingly delicate tuning of values been even slightly upset, the subsequent structure of the universe would have been totally different." "Extraordinary physical coincidences and apparently accidental cooperation . . . offer compelling evidence that something is 'going on' ... A hidden principle seems to be at work, organizing the universe in a coherent way."[12]

Mike Corwin, a physicist, looks over the evolution of the universe from chaos to consciousness, and concludes, "This 20-billion-year journey seems at first glance tortuous and convoluted, and our very existence appears to be the merest happenstance. On closer examination, however, we will see that quite the opposite is true—intelligent life seems predestined from the very beginning. . . . Life as we conceive it demands severe constraints on the initial conditions of the universe. Life and consciousness are not only the direct result of the initial conditions, but could only have resulted from a narrow range of initial conditions. It is not that changes in the initial conditions would have changed the character of life, but rather that any significant change in the initial conditions would have ruled out the possibility of life evolving later. . . . If initial conditions had been different, the universe would have evolved as a lifeless, unconscious entity. Yet here we are, alive and aware, in a universe with just the right ingredients for our existence."[13]

There are all kinds of connections between cosmology on the grandest scale and atomic theory on the minutest scale, and we may well suppose that we humans, who lie in between, stand on the spectrum of these connections. The way the universe is built and the way micronature is built are of a piece with the way humans are built. The shapes of the other regions of the universe, the shapes of all the levels above and below, are crucial to what is now taking place close at hand. In its own haunting way, the physical structure of the astronomical and microphysical world is as prolife as anything we later find in the biological urges. Prelife events can have, and have had, prolife consequences. George Wald says, "Life . . . involves universal aspects. It is a precarious development wherever it occurs. This universe is fit for it: we can imagine others that would not be. Indeed this universe is *only just* fit for it. . . . Sometimes it is as though Nature were trying to tell us something, almost to shake us into listening." "This universe breeds life inevitably."[14]

Manfred Eigen, a thermodynamicist, concludes a long mathematical analysis finding "that the evolution of life . . . must be considered an *inevitable* process despite its indeterminate course."[15] Eric Chaisson, an astronomer, agrees: "A central feature of cosmic evolution, then, is the developing realization that life is a logical consequence of known physical and chemical principles operating within the atomic and molecular realm, and, furthermore and more fundamentally, that the origin of life is a natural consequence of the evolution of that matter. . . . Subtle astrophysical and biochemical processes . . . enable us to recognize the cosmos as the ground and origin of our existence. . . . It's a warmer and friendlier scenario now. . . . We are not independent entities, alien to Earth. The earth in turn is not adrift in a vacuum unrelated to the cosmos. The cosmos itself is no longer cold and hostile—because it is *our* universe. It brought us forth and it maintains our being. We are, in the very literal sense of the words, children of the universe."[16]

3. *Projective Nature: Formed Integrity*

Overlaying anthropic nature on accidental nature, we can still paint a further picture, with some of the old pictures still showing through. I plan to conserve the facts under a different value theory, one neither accidental nor anthropic, but one portraying *projective nature.* Nature's "projects" are regularly valuable, as are its "objects" and its "subjects," sometimes more, sometimes less. True, Earth lies critically on a main sequence, complex with intrinsic values; but it does not follow that non-Earth places are wayward lines without intrinsic value. Analogously to the way in which it is arrogant anthropocentrism for humans to value themselves and disvalue jumping spiders, it is Earth chauvinism for Earthlings to value Earth and disvalue Jupiter. Both the jumping spider and Jupiter are formed in the wonderland of projective nature. There are disanalogies with which we must deal: a jumping spider has organic integrity; Jupiter has site integrity. But both are projects with their glory.

Nature is energetic and fertile, evidenced at length in life and mind. That does involve some accident, but it cannot be all accident; it is an immanent property of systemic nature that natural history results. We live in what K. G. Denbigh calls "an inventive universe."[17] Projective nature is restless. There is a throwing forward of dynamic events that often culminate in natural kinds, products with wholeness—stars, comets, planets, moons, rocks, mountains, crystals, canyons, seas. The biological and psychological processes that on Earth culminate the astronomical and geological processes are still more impressive, but to be impressed with life in isolation from its originating matrix is to have but half the truth. The original meaning *of nature,* from the Latin *natans,* "giving birth," suggests that value in nature lies in its generation of life. A better cue lies in the meaning *of physics,* the Greek word for *nature,* a "bringing forth." Systemic nature is valuable as a productive system, with Earth and its humans only one, even if perhaps the highest in richness or complexity, of its known projects. Nature is of value for its capacity to throw forward all the storied natural history. On that scale, humans on Earth are latecomers, and it seems astronomically arrogant for such late products to say that the system is only of instrumental value, or that not until humans appear to do their valuing does value appear in the universe.

It is less short-sighted but still seriously myopic to value the system only for its production of life, although this is of great moment within it. Nonbiotic things have no information in them, no memory, no genome, much less sentience or experience. There are no cells, no skin, no centered control. Impressed with the display of life and personality on Earth, humans correctly attach an ethical concern to persons and to organisms, but we may incorrectly assume that mere things even on Earth, much less on Mars, are beyond appropriate and inappropriate consideration. The astronomical and geological phases in nature are, on some of their tracks, precursors of life. They are of value on that account, and when life is reached, everything else can seem far "down below," short of the fullness of being displayed in life, and thus without value. But their distance "down below" does not make them merely of instrumental value, nor does it make those places that are "sidetracked" of no value.

All the elevated forms have bubbled up "from below," and the basic stratum is of value for its projective tendencies, which are *value-able, able to produce value* wherever they result in formed integrity. Crystals, volcanoes, geysers, headlands, rivers, springs, cirques, paternoster lakes, buttes, mesas, canyons—these are also among the natural kinds. They are constantly being built, altered, and their identity is in flux. They do not have organic integrity or bounded individuality. They defend nothing. They do not have "character," and there seems in them no conflict and resolution. Nothing there can be afraid, disappointed, frustrated, hurt, or satisfied. So they may seem to have no integrity that can be valued.

But they are recognizably different from their backgrounds and surroundings. They may have striking particularity, symmetry, harmony, grace, spatio-temporal unity and continuity, historical identity, story, even though they are also diffuse, partial, broken. They do not have wills or interests, but rather headings, trajectories, traits, successions, beginnings, endings, cycles, which give them a tectonic integrity. They can be projects of quality.

Nature is not inert and passive until acted upon resourcefully by life and mind. Neither sentience nor consciousness is necessary for inventive processes to occur. There is genesis, Genesis, long before there are genes. Inventiveness in projective nature lies at the root of all value, including sentience and consciousness, and nature's created products regularly have value as inventive achievements. There is a negentropic constructiveness in dialectic with an entropic teardown, a mode of working for which we hardly have yet an adequate scientific much less a valuational theory. Yet this is nature's most striking feature, one which ultimately must be valued and is of value. In one sense we say that nature is indifferent to planets, mountains, rivers, microbes, and trilliums, But in another sense nature has bent toward making and remaking them for several billion years.

These performances are worth noticing—remarkable, memorable—and they are not worth noticing just because of their tendencies to produce something else, certainly not merely because of their tendency to produce this noticing by our subjective human selves. They are loci of value so far as they are products of natural formative processes. The opening movements of a symphony contribute to the power of the finale, but they are not merely of instrumental value; they are of value for what they are in themselves. The splendors of the heavens and the marvels of the geomorphic Earth do not simply lie in their roles as a fertilizer for life. There is value wherever there is positive creativity. It is *productive power,* not merely *experiential power,* that produces value.

It is therefore unfortunate that this protective principle should be termed an anthropic principle, suggesting that the point of the universe is to produce *Homo sapiens,* with its corollary that other phases of the story are errant worlds. It is hubris to believe that everything else in the universe, in all its remotest corners, either has some relevance to our being here or has no value. Nature displays multiple fields of uncontained exuberance, and why should the parts irrelevant to us trouble us? Nor is there any need to cram the universe with other forms of life and mind. Life and mind need only be among nature's interesting products. In truly cosmopolitan moods humans can find all these levels and regions equally required or fitting for the show. Our level is relative among many reference frames. The anthropic principle is a subset within, if also a pinnacle of, projective nature.

It is also inadequate to think of Earthlings as the only fortunate beings in a nature that uses accidents productively. One way of coupling the anthropic and the accidental components is to see Earth as valuable by accident, with Mercury through Pluto valueless by accident, although the system is valuable for its trial-and-error creativity. Those places had to be there for Earth to be here, in the sense that solar systems have to toss out many planets if there is, now and again, to be one right for life. The non-Earths are like mutants in biology; they are astronomical "permutants." Without mutation, life cannot evolve, but most mutants are worthless; only one in a thousand lies on a successful (well-adapted) track. So with the stars and their planets. Most are wastelands, wayward worlds. A few stars become supernovae and cook up elements that will later become planets. A few planets hit the right combination for the main sequence, for life to evolve. This is not luck at the systemic level, since the stochastic system is programmed for permutational experimenting, with statistically probable hits somewhere. But it is local luck. Where there is a positive hit, the life and mind for which the universe is (s)tumbling can be realized. But the other places? They are out of luck, stillborn worlds, dead residues, errors necessary so that there can be successes elsewhere. The universe is mostly full of miscarriages; rarely does it give birth to life and mind. The others are the "noise" that lies in the background of a "significant signal."

Again, without denying that randomness is there with (and for) creative results, are these other worlds nothing but false starts, episodic by-places, valueless satellites because they are not in the main orbit? Whatever truth there is in these accounts, there is a truth more fundamental. The pluralism among planets and moons has an explanation in the principle of projective nature. An astronomer is perhaps entitled to think of these things as having only trajectory courses, but a philosopher can think further of projectory courses. That is, these worlds are thrown forward in a weak, nonteleological sense, yet still a spontaneously constructive sense. Part of the coherence of the system is that it invents diversity. So the diversity is not merely accidental. It is intrinsic to the system to spin off unique projects.

The display of planets and moons has indeed resulted from accidents and impingements of related and unrelated causal lines. The planets fell where they fell in their orbits, captured the moons they captured, collided with the meteoroids they accreted, with relative or even absolute randomness; but the cosmic panorama both is and is not accidental. The solar system is a kaleidoscope, and any particular display may mix related and unrelated causal lines, relative and absolute randomness. But that there will be a diverse display—this is not random but the inexorable outcome of a restlessly projective nature, The solar system is, like a "kaleidoscope" etymologically, a system that tumbles through formed beauty.

(1) In earthen *biological diversity*, mutations occur at random, Sometimes this is with absolute randomness; there is no set of sufficient causes in the quantum range when radioactive decay produces radiation that triggers a mutation. Sometimes this is with relative randomness; the causal chains lie all in place but were previously dissociated, as when accidentally ingesting a chemical mutagen precipitates a mutation. One may ask, "Why is

this mutation there?" and give only the reply, "It occurs randomly." But when one asks, "Why is randomness there?" one is less tempted to reply that it is only random that randomness is there. Randomness is as intrinsic to the system as are matter and energy, and biological systems have learned to use it as a diversifier capturing by natural selection random events advantageous to specific lifelines, building from zero to five million species in as many billion years. Randomness is one of the formative principles.

(2) In *human psychological diversity,* ideas pop into our minds. Whether this is with absolute or relative randomness we hardly know enough brain physiology to say. These ideas mix with causal and logical lines operating within our psychology; they mix with sociological forces and ideologies, and the resulting achievements of thought and culture are quite diverse. There is rational ity here, mixed with personal and social decisions and with related and unrelated interactions of cultural and biological lines. If one asks, "Why were transistors, or steam engines, or wheels discovered just when and where they were?" the answer will contain some causes, some reasons, some randomness. But if one asks whether personalities, societies, cultures will take diverse patterns, the answer is, "They are certain to do so, because psychological and social systems are intrinsically diversifying systems."

(3) In earthen *georphological diversity,* no two places are alike—no two mountains, canyons, rivers, islands, continents, tectonic plates, climatic regimens. Each has its distinctive individuality. Again, there are related and unrelated causal lines, there is relative and absolute randomness, so that any specific outcome is only partially predictable or even explainable in retrospect. If one asks

why the Colorado River meanders through the Grand Canyon as it does, with Hance Rapids here and not a half mile west on the same hard strata, the answer contains mixed elements of causation, initial historical conditions that no theory can supply, and perhaps even genuine indeterminacies. But that the Earth is varied topographically is no accident; it is intrinsic to the system to churn landscapes and seascapes, mixing geomorphic principles with enough openness that the resulting diversity never ceases from poles to equator, Paleozoic Era to the present.

(4) In the *solar-systemic diversity,* forerunning the geomorphic, biological, psychological, and social diversities, we confront a similar principle. The unconscious mind is a random idea generator; the genetic system is a random species generator; the geomorphic forces are random landscape generators. The solar-planetary forces are random world generators. The whole spectrum is random project generation. But the randomness is not chaotic; it is creative. Astronomical nature is *drifting through a project search,* simpler than but analogous to the way biological mutations and psychological trial and error are not worthless but a drifting through an information search. What is going on is systematic compositional permutation, the spontaneous appearance of collective order. Something is at work diversifying the material.

(5) In the *galactic diversity,* we can detect projective nature from the start. The energy unleashed at the big bang is turbulently formative; one peculiarity is how it clumps into galaxies and stars. Just where and why it clots this star, Alpha Centauri, and those galaxies, the Magellanic Clouds, we cannot say. Some suppose these locations result from random indeterminacies near the start. But star events in the number 10^{22} and galaxy

events in the number 10^9, though each may have random factors involving precise location or size, cannot as a statistical tendency be random. This must reflect a law of nature.

A further peculiarity is how certain stars forge the heavier elements, iron, silicon, and the rest, with carbon just managing to form and just managing to escape complete conversion to oxygen. Again, factors here may be random, but that somewhere, sometime, the ninety-odd elements are produced in felicitous proportions—this process, which goes on in billions of stars, cannot be random. It is a formative principle immanent in matter and energy.

A further repeated tendency is for certain stars to explode themselves as supernovae yielding clouds of dust and gas, with such clouds falling in on themselves under their gravity, yet not entirely so. Some chunks get knocked out in the rotating collapsing mass, yielding a great platter about a star's equator. The forces that produced the rings of Saturn or the Galilean moons of Jupiter seem similar to those that produced the solar system, similar to those that rotate the galaxies. Something makes a platter, a protosun at the center; something sweeps up orbiting planets rather than plunges all into the sun. Humans have been ignorant, at least until recently, whether there exist any other solar-planetary systems; but the tendency to clot, differentiate, to collapse and nucleate, to spin and rotate is so pronounced in the universe that our solar system must be an instance of a more pervasive tendency. The dark companion to Barnard's Star, the ring thought to be planets around Fomalhaut, the preplanetary system around Vega, or the streaks of light around Beta Pictoris are beginning to supply empirical evidence that our solar system is not just a freak accident.[18]

One principle here is called a tendency to collapse, as when a galaxy, star, or dust cloud collapses on itself, But the "collapse" so called is matter prone to gravitational alliance with itself, yet in such a way that the swirling, differentiating result is a tendency to construct as much as to collapse. Gravitation couples dust to dust, clump to clump, and spins and heats the whole. The gravitating is counterbalanced by electromagnetic forces, tending to prevent overcollapse into black holes, and protracting the life of stars as sources of materials and energy. The result creates temperature differentials in aggregates kept in turbulence, energy irradiated over matter, all of which is order waiting to happen.

After moral consciousness arises, there can be evil creativity, Perhaps there can be disvaluable creativity within ecosystems, when a new organism evolves to ruin an ecosystem, although the principle that only the better adapted within their communities survive protects against this. But at astronomical levels, it is difficult to think what bad creativity would mean. Nor does a systemically projective nature suppose that all astronomical events are creative. Some are destructive, as when an asteroid crashes into a planet with highly developed landscapes, perhaps even one with ecosystems. Destructions may be inevitable if there is to be perpetually rechurning creativity, an astronomical parallel to the way that biological death is required for there to be ongoing evolutionary life. The destruction of stars as supernovae seeds the matter that later collects into planets. Things are perpetually destroyed, but their destructions are regularly preludes to re-creations. What the model of projective nature finds is a systemically positive creativity that moves events—at least at fertile locations and over significant stretches of time—higher upslope than the destructive forces move events downslope. At such place-time locations there is recurrent formed integrity. This does not have to be uninterrupted, and it will not be unending. Yet if this stops at one place, it will reappear elsewhere.

4. Solar-Planetary Nature: Distinctive World Histories

Now we can think more particularly of the non-Earth places not so much as accidental mutants but rather using a model of other "species," other world kinds with alien integrity. We can appreciate the order that has happened there for what it is in itself, and not from a human point of view. The nine planets and thirty-six moons, together with minor planets, Apollo objects, comets, planetesimals, thousands of asteroids, and millions of meteoroids, are proving fascinating beyond expectation. The planets show an extraordinary diversity, and their moons not less so. There are twenty-five worlds larger than a thousand kilometers across, several thousand worlds big enough to land a spaceship on. Differences in body size, composition, density, mass, gravity, magnetic fields, distance from the Sun, axial tilt, rotation-to-orbit time ratios, thermal conditions, radioactivity, photodissociation by sunlight, clouds, circulation patterns, equilibrium mechanisms—all result in complex interactions that make each place a different story.[19]

The inner planets are rocky; the outer gaseous or icy. Jupiter is over a thousand times the volume of the Earth. The pressure at the surface of Venus is a hundred Earth atmospheres; the temperature 400° C. Jupiter and Saturn seem to have no surface at all, becoming gradually more dense with depth. Only Earth seems to have tectonic plates, although Mars, Mercury, Europa, Ganymede, and probably Venus have crustal fracturing. The atmospheres of the planets (on all but Mercury and possibly Pluto) and even on some moons (Titan) vary widely. Some atmospheres (Earth, Venus, Mars) evolve dramatically. Wind velocities at Saturn's equator can reach 450 m/sec. In addition to Jupiter's array of moons, it has two sets of Trojan asteroids locked into its orbit, proceeding fore and aft. Io is bizarre, perpetually in volcanic convulsions, heated by an eccentric orbit around massive Jupiter, causing frictional tides. Orbiting in Jupiter's giant magnetic field, Io generates a massive electric current, 5 million amperes. The magnetosphere of Jupiter, a pulsing field, if we could see it in the night *sky,* would be several times as large as the moon. Ganymede and Callisto, which might have been thought similar, have quite different histories.

On Jupiter and Venus there are auroras and lightning. The F-ring of Saturn contains five components in irregular, interweaving orbits that no present theory of orbital dynamics adequately explains. Saturn displays 100,000 discrete rings. Earth and its moon are quite dissimilar companions; the Moon has proved more complex and evolved than expected, although waterless, airless, lifeless; and scientists are puzzled how these two came into their binary partnership. A fresh challenge to solar science is to explain why planets, moons, asteroids are as varied as they are.

Possibly we are dealing with a pluralism that has no principled unity. The solar "system" so called is not a coherent system; the planets and moons are isolated worlds with little in common, nothing past the physics, chemistry, and geomorphologies they share. They may once have had common causal lines or origins, mixed with many nonrelated causal lines. But these have since separated; each world goes its own, unrelated way. Never do they meet. After all, many other parts of our universe are out of causal contact with each other. We should not speak of astronomical *nature* in the singular; there are only local and multiple *natures* in unrelated worlds.

Possibly the sorts of questions later generated on Earth, a place of value, about whether these other worlds also have value is a misplaced question, an interplanetary category mistake. We ought not ask whether they have value; this is an earthbound question that cannot be asked there, something like asking whether it is 9:00 P.M. Eastern Standard Time on Pluto, or whether the enormous collision that nearly destroyed Mimas might have happened on a Tuesday. The value question, so far as it can be asked, is an exported question, which can only be related to Earthlings' needs or interests. It cannot be asked intrinsically, neither from the point of view of a planet-in-itself, nor systemically from the point of view of the Solar System. Alien planets and solar systems do not have value points of view; only Earthlings do.

But possibly we can learn to ask value questions in nonearthbound ways, and interpret what is happening on the planets as continued formative activity, Take cratering, for instance. This batters and saturates the terrestrial planetary landscapes and seems chaotic and valueless. But these collisions, which only leave meaningless scars from one perspective, are from another perspective the operation of the gravitational forces that swept up the planets in the first place. What is sporadic on short time scales (an occasional meteor crash) is systemic on larger time scales (the collecting of local worlds). These impacts fuse pacts of matter. Without this accreting of chunks, there would have been no Earth, no life, no persons. One cause of the emptiness in interplanetary space is that matter is swept up into planets and moons, and in this sense emptiness in space is the obverse of constructiveness in projective nature, which has gathered up the puzzle pieces. There is emptiness there because there is something here.[20]

With the manufacturing of land comes the manufacturing of landscapes. As the terrestrial planets are formed, impact cratering subsides, but enough continues to churn relief. Further, volcanism and tectonic movements appear, widespread and powerful. Olympus Mons, a volcano on Mars, approaches the size of Texas. Crustal fracturing is found on Mars and Mercury, on Europa and Ganymede, and probably on Venus. Planets and moons often have (or have had) internal heat engines, which further churn relief. Lava flooding is present on the Moon (the mare regions). Even the "dead" scenes have been active at previous times.

Weathering and erosion erase what volcanism, tectonic movements, and impact cratering have constructed, and yet these too are constructive forces. Where there is an atmosphere (Earth, Mars, Venus, Titan) moving over a surface, meteorological forces transport materials and erase landscapes (now combining with the gravity that, earlier, was crucial for accretion). Where there is liquid—water, methane, carbon-dioxide glaciers, lava—fluvial erosion can take place (on Earth, Mars, perhaps Titan). These morphological and orogenie forces interplay and carve landscapes. Anyone who appreciates rugged landscapes (cliffs, gorges, expanses) on Earth will delight in the Valles Marineris on Mars, with canyons four times as deep as the Grand Canyon and as long as the United States is wide. Any Earthling who enjoys watching weather fronts and storm clouds will find awesome the storms on Jupiter.

Each new world, each place in that world, will be a novel topography, more or less interesting, but never uninteresting, just as each landscape on Earth is a new twist to the kaleidoscope. Though the other planets are places of limited possibility, at least in their present states, they are also places where formative nature is creatively at work. Some things will be interesting because they are further expressions of familiar laws of nature extrapolated from Earth: the elements, the atomic table, chemistries, the 32 crystal classes, often the mineralogies and rock types. Yet each world will also be interesting because its particular phenomena actualize potential unknown on Earth. The language currently preferred (because it has a ring of scientific respectability) is of the "evolution" of each planet and place. What is really meant is that each location has its own history.

On the basis of what we know from chemistry, physics, geomorphology, meteorology, mineralogy, and petrology, solar scientists might think they can predict what we will find before we explore a new planet. But this will not be entirely so. Physicists and chemists have often anticipated what they would next find: the neutrino, helium in the atomic table. Astronomy is often a highly predictive science. Neptune and Pluto were predicted before they were seen, as was the bending of light near the Sun and the spiraling solar wind. Orbits and eclipses can be predicted centuries ahead,

By contrast biology has been a poorly predictive science. The organelles in the cell—the nucleus, chromosomes, mitochondria, plasmids—were surprises. One can never predict, before examining a new plant, what alkaloids it contains, and thus the vincristine in *Catharanthus roseus* came unsuspected. One can never say, before exploring a hitherto unknown lake, island, or tropical forest just what is there, especially if isolated from already known faunas and floras and speciation has been at work. The discovery of *Catagonus,* an "extinct" peccary alive in Paraguay, came as a surprise. This is because biology is full of history as physics and chemistry are not.

We are learning that solar science, too, despite its laws, is full of history. Each planet, moon, place is going to have its own story, a unique world that cannot be predicted in advance, not entirely, not in many interesting details, but which can be enjoyed only upon discovery. So it was with the odd orbits of Nereid and Triton, Neptune's moons, with the rings of Uranus, and its rotational axis in the plane of its orbit, with Pluto's companion, Charon, with the frenzied activity on Io, and so it will be with whether Saturn has D, E, and G rings, Bradford Smith, a team leader on the Voyager missions, said, "I don't think we could have been more wrong in predicting what we would see on the Galilean satellites."[21] What Voyager found that was unexpected was the equal of what Magellan found that was unexpected.

Celestial mechanics calculates results so beautifully just because it leaves out the "personalities" of the planets. Where and what size a planet is, its axial tilt, how many moons it has, whether these were spinoffs from the parent or gained by capture, what their orbits are, whether a planet or moon has an atmosphere, its meteorology, its magnetic field, its magnetosphere, what volcanic eruptions have taken place, whether a planet radiates more heat than it receives from the Sun—such characteristics can be suspected but are derivable from no theory plus initial conditions. Initial conditions, which are themselves history, couple with laws of nature and perhaps with genuine indeterminacies; knowns mix with unknowns to drive storied developments, kaleidoscopes of related and unrelated causal lines, relative and perhaps even absolute randomness, all products of interesting diversity. There will be order with spontaneity, constancy with contingency. We can predict only parts of the stories. We can predict that there will be surprises, and that many of the surprises will be worlds of strange integrity.

The technical way of saying this is that solar science, as well as interstellar astronomy, is going to be as idiographic as it is nomothetic. A plain way of saying this is that these planets, places, projects will routinely command proper names.

5. *Preserving Nature: Respecting Projective Integrity*

Humans ought to preserve projects of formed integrity, wherever found. Already operating in earthbound environmental ethics, this principle underlies respect for life, organic individuals, species, ecosystems, landscapes. Humans themselves are a lofty expression of this creativity; the mind and hand epitomize creativity, and our own continuing creativity (expressed in human capacities for space travel, for understanding alien places, for use of nonearthen resources) is also to be respected. This licenses the exploration and even the exploitation of space. But just as the human dominion on Earth is constrained by a respect for other forms of being, the human presence in space, which is neither our dominion nor our native domicile, ought to be constrained by a respect for alien forms of projective integrity. If an ethicist shrinks from the vocabulary of *duty* here, there will be *ideals of attitude* toward these places.

Can this be expressed in more detail? Two caveats follow, with six preliminary rules for nature preservation in the solar system, A first warning: Humans are now in a poor position to say what the formed integrities elsewhere in the solar system are. Speculating over what places, planets, moons should be designated as nature preserves would be more foolish than for Columbus to have worried over what areas of the New World should be set aside as national parks and wildernesses. All the same, in retrospect, our forefathers would have left us a better New World had they been concerned sooner about preserving what they found there, not as early as the fifteenth century but neither as late as the nineteenth and twentieth centuries. Let the twenty-first, the twenty-second, and the twenty-third centuries profit by the mistakes of the sixteenth, seventeenth, and eighteenth. Earthlings have little power to affect extraterrestrial places today, but then the Pilgrim Fathers posed little threat to the ozone layer with fluorocarbons, nor to genetic processes through plutonium radioactivity.

A second warning: Banish soon and forever the bias that only habitable places are good ones (temperature 0-30 degrees C., with soil, water, breathable air), and all uninhabitable places empty wastes, piles of dull stones, dreary, desolate swirls of gases. To ask what these worlds *are good for* prevents asking whether these worlds *are good* in deeper senses. The class of habitable places is only a subset of the class of valuable places. To fail as functional for Earth-based life is not to fail on form, beauty, spectacular eventfulness. Even on Earth humans have learned, tardily, to value landscapes and seascapes that have little or nothing to do with human comfort (Antarctica, the Sahara, marine depths). Just as there is appropriate behavior before Earthen places, regardless of their hospitality for human life, so there will be appropriate (and inappropriate) behavior before Martian landscapes and Jovian atmospheric seas.

These other worlds are not places that failed. Nature never fails. Nature only succeeds more or less with its projective integrity. We do not condemn a rock because it failed to be a tree, though we may value it less than a tree. We do not condemn a tree because it failed to be a person, though we may value it less than a person. We ought not condemn Mars because it failed to be Earth, although we may value it less than Earth. There may be fewer formed integrities on Neptune, but there will be some that do not exist on Earth. Learning to appreciate these alien places for what they are in themselves, not depreciating them for what they failed to be, will provide an ultimate test in nature appreciation. Only as we allow that it is good that Apollo asteroids are of no "earthly use" will we learn whether they are an outlandish good.

After these warnings, we can think more positively. The following rules probe toward an exploration ethic.

(i) *Respect any natural place spontaneously worthy of a proper name.* Projective nature is valuable at the systemic level; and there results a kind of baseline value in every rock and cloud, since even the simplest things are products of nature's creativity. But such value is so pervasive and relatively minimal (though absolutely impressive) that it cannot be made operational. Many products of nature (meteoroids, lava flows, dust clouds) have insufficient projective integrity to warrant particular respect or admiration. Others do, and one way to test for these is to see whether an entity commands a proper name. Proper names are often tags for the convenience of geographers and mapmakers (the Four Corners Area, the Hellas Basin) or needed for historical reasons (Plymouth Rock, Halley's Comet), and humans sometimes give their artifacts (cities, nations) proper names. Proper names given for other reasons are not sufficient to warrant protection. But some places seem to warrant proper names for what they spontaneously are in themselves. If so, that signals our perception of enough topographic integrity to enter its protection into the calculus of trade-offs. This protection should be at something like the level of scope to which the proper name attaches. Such a place will have features, differentiation from elsewhere, peculiarity of form, ensemble of components, gestalt and mood, all of which are ingredients of formed integrity.

In this sense we will probably not come to feel that humans have duties to every crater on the Moon or to each solar flare because these places/events as such have little integrated process in them. But by the time we are drawn to attach a proper name to a place, there is enough particularity, differentiation and integration of locus, enough provincial identity to call for protection. This does not address the question how much these places count; it only locates one particular sort of thing that can come to count operationally in an extraterrestrial ethic. We might also want to preserve representative types, but what one is respecting here is not generic landscapes but particular locality.

As test cases, one might ask whether to preserve Phobas or the Great Red Spot on Jupiter. We can imagine (in the not-too-distant future) military commanders testing to see whether they had enough nuclear muscle to blow these places to smithereens. The rule here is that such testing should not, without overriding justification, destroy places with enough site integrity to command proper names.

(2) *Respect exotic extremes in natural projects.* On worlds elsewhere and elsewhen nature will give expression to potential that could not be realized on Earth. This will always be true more or less, but where true the more, where there is salient quantity, quality, or natural kind, that will be reason for appreciating notable formed in-

tegrity. Just as humans value diversity on Earth, humans should value diversity in the solar system, all part of the robust richness of nature. For instance, rock volcanoes and the basalt they spout will be common both on Earth and elsewhere, but volcanoes of ice, spouting lava made of ammonia and water, or liquid methane seas may exist on Titan and not elsewhere. Saturn's splendid rings may be unexcelled in many solar systems. Jupiter's ring may be dynamic, steadily lost into Jupiter's atmosphere and replenished, by material supplied from satellites just outside it, as Saturn's rings are not. That a formative event in nature is rare is, *prima facie,* reason for its preservation. At such places humans can learn something about the of things, the *nature* in things.

The second rule extends the first in that humans respect phenomena in addition to places, extremes in systemic expression, regardless of whether they call forth proper names. Such events are, to twist a phrase of astronomers, singularities—not naked singularities but idiomorphic ones. To play with a phrase of particle physicists, we ought to conserve strangeness. This can be interpreted, if one prefers, as an ideal of human excellence, but it can be interpreted as well in terms of respect for "excellences" (= exuberances) in projective nature. These are places where humans get flung into wildness and magnificence unbounded by earthly constraints. If Earthlings consider only whether these places have functional utility, our experience can be of futility or horror; but if we consider the expressions of which nature is capable, the experience can be of amazement in wonderland.

(3) *Respect places of historical value.* Some planets, moons, places do not merely spin; they spin stories. They have their "once upon a time," their "long ago and far away," their "fortunes." Some have more story than

others. History is nowhere even-textured and homogeneous. Although all events are contained in history, they are not equally critical or significant historically. In earthbound history, some decades, centuries, persons, nations, species, mutations have more import for the ongoing story. Astronomical nature too is historical, usually at a slower pace, at least from our inertial reference frame; but there too are flux and change, beginnings and endings, turning points.

Humans ought to preserve those places that have been more eventful than others. The places where water flows or has flowed (only on Mars?) will be of special interest. Some planets, moons, cratered plains, fault canyons, mountain ranges provide more complex books to be read. Some are palimpsests, canvases with the new painted over the old. Some provide fossil evidence for the history of the solar system in ways that others do not. Callisto is a 120-degree-K ice museum of a bombardment period four billion years ago. Some may once have had life, or have made near approaches to it, of which evidence is left. The Moon, Mars, and Mercury are senile landscapes. From the rule to follow, this provides a reason not to preserve them; but we have here to notice that they are museum places where the records have been kept from the first two-and-a-half billion years of planetary evolution, and that is reason for preserving their richest landscapes. So we might permit engineers to simulate a nuclear meltdown on Mare Imbrium, but not in Tycho, the great rayed crater, since the latter is of historical interest as the former is not.

This rule can, like the others, be interpreted humanistically as saving these stories for humans to read. But it can better be interpreted as recognizing that projective nature is a historical system, a book that writes itself, and that one human value is being let in on this valuable eventfulness, these histories spun entirely apart from the human presence,

In combination, the preceding rules should preserve places of high scientific value.

(4) *Respect places of active and potential creativity.* Some places, planets, moons will be more energetic than others, perhaps on geological scales, perhaps volatile and ephemeral. Others will be stillborn, quiescent, others senile. By this criterion, Earth's moon is inactive; Jupiter is dynamic. By contrast with the ancient surface of Callisto, the surface of Io is as young as yesterday. Some of these places may, in a future epoch, when the Sun explodes, become habitats for life. We want to respect the hot spots of projective nature. We protect generativity; we keep open the theatre. We mistreat nature to see it as inert and passive, as dumb stuff, unless and until activated and enlightened by mind. Rule 4 is the forward-looking complement to Rule 3, a retrospective rule.

Over perhaps five billion years, the evolutionary development on Earth has climbed from zero to over five million species. A deplorable thing that the lately arrived humans are doing is shutting down the speciation processes by habitat depletion and extinctions, at a rate that is potentially catastrophic. They are thwarting the formative biological processes. Similarly, we ought not to degrade the solar-planetary creativity. In the solar system, as much time lies ahead as behind us (perhaps five billion years in both directions). Perhaps Earthlings cannot greatly affect the solar-systemic evolution on broad scales; but perhaps they can shut down locales of active development, and that would be a pity.

All the planetary places are energy knots in a restlessly active space-time plasma/ether. Even the coolest of them—Pluto and Charon—are freeze-dried energy, coalesced in what is only an apparent void. The "hottest places"—not in terms of degrees Kelvin but in terms of energy irradiated over matter in formative thermal ranges—deserve special consideration. A planet, or a place on it, not less than a particle, is a manifestation of the great underlying process, and where that process is especially pregnant, humans ought to respect the pregnancy. This can, again, be an ideal of human excellence, but it can be a respect for "excellences," creativity in projective nature,

(5) *Respect places of aesthetic value.* Some planets, moons, comets will have more symmetry, harmony, elegance, beauty, grandeur than others, and this counts for their preservation, Aesthetic value is always present with formed integrity, although aesthetics is not the only category through which such integrity is to be interpreted. Complexity, fertility, rarity, information content, historical significance, potential for development, and stability are others. Nevertheless, aesthetic properties are high-order value properties and should be preserved in the degree to which they are present. Such scenes are the "pictures" that illustrate the historical "text." They provide the "poetry" that graces the "prose," excellences that register on sensitive beholders as they come under the sway of creativity inherent in solar-planetary nature. Out there experiences of the sublime hitherto unknown await us, and respect is demanded in the presence of the overwhelmingly sublime.

(6) *Respect places of transformative value.*[22] A major theme during the last four centuries has been widening human horizons. Humans have become modern as they have gained awareness of the depths of historical change, of the diversity and extent of creation, of the magnitude of time and space. Astronomers with their telescopes, biologists with their microscopes, taxonomists with their phylogenetic trees, geographers with

their travels, along with others such as geomorphologists, paleontologists, archaeologists, anthropologists, have widened our vistas. Space exploration is writing still a further chapter in the story of pushing back horizons.

Humans ought to preserve those places that radically transform perspective, Just as it was a good thing for medieval Europe to be dislodged from its insularity, challenged by the Enlightenment and the Scientific Revolution, it will be a good thing for Earthlings to be unleashed from the Earth-givens. We can reduce human provinciality with the diverse provinces of solar-planetary nature. In space, so much is scrambled—what counts as day or night, year or season, hot or cold, up or down, bizarre or normal, what counts as land, sea, sky, the feel of gravity. These disorienting, unsettling discoveries will expand our juvenile perspectives. For intellectual and moral growth one wants alien places that utterly renegotiate everything in native ranges. These will prove *radical* places to understand, not merely in the anthropic sense that our *roots* lie there, but in the nonanthropic sense that they *uproot* us from home and force us to grow by assimilating the giddy depths and breadth of being. Those who cannot be seriously confounded by nature have not yet seriously confronted it.

Some will say that this makes instrumental use of solar-planetary nature, finding its appreciation a means to larger human experiences. We preserve those places that act as intellectual fertilizer. That is true, but not the end of the account. Sooner or later, humans will concede that these places have high transformative value because they have exotic formed integrity. They fertilize the human mind because nature is creatively projecting something there. In this sense Rule 6 is the upshot of Rules 1 through 5.

A principal thing to get transformed in space is our earthbound value system. Out there few places are warm or comfortable, there is no sentience, no pain, pleasure, interests, much less felt preferences satisfied. There is no resource use, no adaptation for survival, no genetic sets defended. Nothing seeks anything; there are no means to ends. There is neither love nor freedom. There is only indifference. All is blah! So we incline to judge, from our relative earthen reference frame, that these are valueless places. Values happen on Earth, not elsewhere, unless Earthlings go elsewhere.

But there are mysteries that ride on the Sun's rays, majesties in the swirling gases and chunks of matter, and humans will benefit by learning to see other worlds, other events where they are for what they are, as surely as they benefit by having air, water, and soil. The historical struggle, repeated now in ourselves, has always been to get a big enough picture; and we now stand at an exciting place: one world trying to figure out the others.

The human genius takes an interest outside its own biological sector. Nonhuman species take an interest (biological or psychological) merely within habitat, in prey or predator, in resource or shelter. Only the human species can value at a distance that which does not stand in its own lineage, underpinning, or life-support system. The initial challenge of environmental ethics has been to press that task in the earthen environment. A space ethic extends the challenge into the astronomical environment. We require a space metaphysics to go with space physics. Space exploration must also be value exploration.

Later on, humans become *excited* (in the psychological sense) when they get let in on these things. Earlier on, what is first happening is that these places, planets, moons, with their winds, clouds, tectonic movements, volcanism, electromagnetic fields, are getting *excited* (in the geophysical sense) by energy fluxing over matter, by heat engines within, by solar radiation, by radioactivity, by kinetic and other creative forces of nature. In the order of knowing, the excitement is first in the human beholder and then in the systems beheld. But the excitement, in order of being, is first in objective, energetic, material nature, and only much later in human subjectivity. It need not follow that every excitement of physical nature can or should excite value in a human beholder (not in more than foundational, baseline ways), but the more lofty excitements of physical nature will regularly produce valued excitement in human beholders. Until we have a value theory that takes things in proper order, we have not yet enjoyed the transformative value that solar-planetary nature has to offer.

Some will complain that all this is wrestling with shadows; there is no value in solar-planetary nature, only an illusion that appears when humans come on stage. But I think not; we are wrestling with creativity. Positive creativity is no illusion, but rather the principal value in the universe, from which all else derives, and which above all needs appreciation and protection. Some will complain that, even if there is extraterrestrial value, any present concern about preserving it is far-fetched. Perhaps so, but sooner or later the far-fetched can become farsighted.

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6. For what follows see, in addition to following references, John A. Wheeler, "The Universe as Home for Man," in Owen Gingerich, ed., *The Nature of Scientific Discovery* (Washington, D.C.: Smithsonian Institution Press, 1975), pp. 261-96; also his "Genesis and Observership" in Robert E. Butts and Jaakko Hintikka, eds., *Foundational Problems in the Special Science* (Dordrecht, Holland: D. Reidel Publishing Co., 1977), pp. 3-33.
7. B.J. Carr and MJ. Rees, "The Anthropic Principle and the Structure of the Physical World," *Nature* 278 (1979): 605-12, quotations on pp. 605, 609. See also George Gale, "The Anthropic Principle," *Scientific American* 245, no. 6 (December 1981): 154-71; B. Carter, "Large Number Coincidences and the Anthropic Principle in Cosmology," in M.S. Longair, ed,, *Confrontation of Cosmological Theories with Observational Data* (Dordrecht, Holland: D. Reidel Publishing Co., 1974), pp. 291-98; and John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (New York: Oxford University Press, 1986).
8. Bernard Lovell, "In the Centre of Immensities" (presidential address to the British Association for the Advancement of Science, 27 August 1975), published in part as "Whence?" in the *New York Times Magazine,* 16 November 1975, pp. 27, 72-95, citation on p, 88, p. 95. See also Bernard Lovell, *In the Center of Immensities* (New York: Harper and Row, 1978), pp. 123-26. On the other hand, if the same force (the strong nuclear force) were a few percent weaker, only hydrogen could exist.
9. Freeman J. Dyson, "Energy in the Universe," *Scientific American* 225, no. 3 (September 1971): 50-59, citation on p. 59.
10. Fred Hoyle, "The Universe: Past and Present Reflections," *Engineering and Science* 45, no, 2 (November 1981): 8-12, citation on

p. 12. See Hoyle's "On Nuclear Reactions Occurring in Very Hot Stars, I. The Synthesis of Elements from Carbon to Nickel," *The Astrophysical Journal*, Supplement Series, 1(1954): 121-46.

11. Marek Demianski, quoted at the Conference on Quantum Theory and Gravitation, Loyola University, 1983, in Dietrick E. Thomsen, "In the Beginning Was Quantum Gravity," *Science News* 124, no. 10 (3 September 1983): 152-57, citation on p. 152.
12. P.C.W. Davies, *The Accidental Universe* (New York: Cambridge University Press, 1982), pp. 90, 110.
13. Mike Corwin, "From Chaos to Consciousness," *Astronomy* 11, no. 2 (February 1983): 14-22, citations on pp. 16-17, 19.
14. Wald, "Fitness in the Universe: Choices and Necessities," p. 8f.
15. Manfred Eigen, "Self-organization of Matter and the Evolution of Biological Macromolecules," *Die Naturwissenschaften* 58 (1971): 465-523, citation on p. 519.
16. Eric Chaisson, "The Scenario of Cosmic Evolution," *Harvard Magazine* 80, no. 2 (November-December 1977): 21-33, citations on pp. 29, 33.
17. K.G. Denbigh, *An Inventive Universe* (New York: George Braziller, 1975.
18. M, Mitchell Waldrop, "First Sightings," *Science 85* 6, no. 5 (June 1985): 26-33.
19. Most of the empirical facts in what follows can be found in J, Kelly Beatty, Brian O'Leary, and Andrew Chaikin, eds., *The New Solar System*, 2nd ed. (Cambridge, Mass.: Sky Publishing Co., 1982) or in G.A. Briggs and F.W. Taylor, *The Cambridge Photo graphic Atlas of the Planets* (Cambridge, England: Cambridge University Press, 1982).
20. In a still more fundamental sense, all matter and energy are a warp, crinkle, bubble in space-time, so that the space-time "emptiness" is really the "fullness" out of which everything appears
21. Bradford A. Smith, "The Voyager Encounters," in Beatty et al, *The New Solar System*, and. ed. (Cambridge, Mass.: Sky Publishing Co., 1982): pp. 105-16, citation on p. 109.

22 Adapting a phrase used by Bryan Norton in the context of preserving Earth's biological species. The author also appreciates the criticisms of J. Baird Callicott.