

The Ancient and Future Art of Terraforming

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BETWEEN ROUGHLY TWO BILLION AND ONE BILLION YEARS ago the first known terraforming event took place on this planet, the Oxygen Catastrophe. During this event, cyanobacteria used photosynthesis to fix nitrogen and build robust adaptive structures in the reducing atmosphere of the early Earth, and in the process they excreted oxygen in global quantities. Once all the iron on the Earth's surface had rusted, absorbing as much oxygen as it could, the planet's atmosphere changed radically, into something close to what it is today.

Stromatolites, corals and shellfish changed the geology of the planet, creating colossal limestone deposits which, when subducted under the mantle, caused new forms of volcanic and rifting activity. Hydrocarbons were laid down by plants. The colonization of the land by arthropods, insects, and vertebrates was a similarly dramatic event, as was the evolution of the angiosperms, the flowering plants. Termites and ungulates produced greenhouse gases; worms and grasses changed the soils; beavers altered watersheds profoundly; climax forests changed the local climates.

In the Anthropocene epoch, a new terraformer entered the scene. Human hunter-gatherers may have been using fire at least 20,000 years ago, as they do today, to destroy scrub and forest to provide fresh grazing for game. The extinction of large fauna across the Americas and Australia tracks the human colonization of both continents, and huge areas of Europe and North America are only now becoming reforested after their Paleolithic transformation into grassland. Some have suggested that early herders contributed to the desertification of much of Africa and Asia. Were the increasingly frequent ice ages themselves affected by intelligent vertebrate behavior?

Agriculture is perhaps humanity's largest and most radical effort at terraforming. Beginning about 11,000 years ago it had transformed the planet. The dust-bowls of America and Asia, the drying up of the Aral Sea, the reduction of the Mississippi delta, the saline poisoning of the soil in Mesopotamia and Egypt, and so on, are obvious results of such industrial-age events as the farming of the prairies and the damming of the great rivers, as are of course the rise in greenhouse gases and global climate change. But such changes are not new.

The point is that we in our time did not create the issue of anthropogenic terrestrial change, but stepped into it; before the advent of humans, the Earth was always already in a state of crisis and emergence. The big mistake is to imagine a state of the planet that was ever in balance and harmony. Certainly humans have moved very fast in altering the planet, but many purely "natural" events have moved even faster, like major volcanic explosions that cause planetary winter, the breakthrough of slowly rising oceans into millions of square miles of lowland (the flooding of the Mediterranean and Black Sea basins, the emptying of Lake Agassiz in what is now Canada, etc), the joining or separation of continents, the emergence of volcanic islands, and the impact of supermeteors like the one at Chicxulub in the Yucatán Peninsula.

Life, and human life par excellence, is enormously adaptive, innovative, and constitutively emergent. Harmonious balance is a rare and temporary achievement, a synergetic resolution of otherwise destructive forces. The beautiful and complex forms that DNA assumes are the result of an enormous abundance, an exuberant process of niche-creation and niche-discovery; they are not the precious fragile remnants of a greater and better past order. We took too seriously, perhaps, our nineteenth-century discovery of the second law of thermodynamics and the increase of entropy or thermal disorder over time. What we thought was the enemy of life was actually its fuel, like the oxygen that the early phyla excreted into the atmosphere of the young Earth. Life *runs* on decay.

In this perspective it might be worth re-evaluating our whole contemporary discourse of the environment, and especially of the problems we face and the measures that have been proposed for their amelioration. Most salient of all, perhaps, is the issue of our responsibility for the planet and the technological means that we have for fulfilling it. But the issue is larger still—our environment is not just this planet, but the solar system too, at least. Many ethical arguments about whether we should leave other planets to their own destiny may be rendered moot by the strong possibility that, first, life on Earth may have already seeded or been seeded by exchanges of DNA between planets by impactor collisions, so that it is the solar system, not the planet, that is the relevant ecosystem and, second, DNA may be universal, hugely abundant, and not endangered, and our duty is general solidarity and interaction with biota everywhere. The existentialist

vision was one in which we fancied ourselves as alone in an alien universe; it is now beginning to look as if we were at home all along, in a very big house indeed.¹

We are already embarked. The planet is a self-terraforming place, and an acceleratingly self-terraforming place. We are only the most potent agent of the planet in this enterprise. Which means both that we should be extra careful, *and* that we sit as many risks, as Thoreau said, as we run. Inaction on global climate change may be much more dangerous than action.

So the whole question of our responsibility for the planet turns on how it is imaginatively conceived—a matter of culture, philosophy, ideology, poetry. Only if our imaginative net is wide enough will we be able to capture the good hard facts that really put the case in perspective. If we have a hammer, everything looks like a nail: and this limitation applies just as much to the environmental ethicist as to the pragmatic engineer.

The best things that ever happened to the human species—the obsolescence of slavery, the (advancing) liberation of women, the staggering recent increases in longevity, literacy, prosperity, public health, rule of law, democratic governance, and the economies of the marketplace—are all based on the progress of science and technology. That progress is built upon the concept of consilience, that is, a fundamental coherence and unity in the world. Modernity—now usually redefined to include the Renaissance—has been a state of debate and argument about the “magisterium” of that notional unity. Is it to be understood by reduction, deconstruction, and the assumption of determinism, or by the concepts of emergence, evolution, and the common origins of very different outcomes?

For my money, the Renaissance, in the old sense of the fourteenth through seventeenth century period of discovery, had it right the first time. There is a wonderful exchange on this problem in Shakespeare's *The Winter's Tale*. The shepherdess Perdita, according to custom, has been giving flowers to the guests at her feast. But she doesn't like the fancier, cultivated flowers of the time.

PERDITA Sir, the year growing ancient,
Not yet on summer's death, nor on the birth
Of trembling winter, the fairest flowers o' th' season
Are our carnations and streaked gillyvors,

Which some call Nature's bastards; of that kind
Our rustic garden's barren; and I care not
To get slips of them.

¹ A universe of living abundance—which may well be the case—would render invalid systems that presuppose a fixed or diminishing stock of value in the universe, such as Nordic paganism, feudalism, Malthusian mercantilism, religious millenarianism or predestinarianism, Marxism, and Trumpism. All such systems imply a death-struggle for the possession and consumption of a limited stockpile.

She refuses to grow the gaudier, “fairer,” late summer and early fall flowers, hinting that there is something improper in their ancestry. A “slip” is a cutting, from which a new plant can be propagated or cloned. Her guest Polixenes pursues the matter, intrigued by Perdita’s evident discernment, eloquence, and strength of mind.

POLIXENES Wherefore, gentle maiden,
Do you neglect them?

PERDITA For I have heard it said,
There is an art, which in their piedness shares
With great creating Nature.

But now she has opened up one of the perennial questions of philosophy. What she has just said is that she objects to the art of selective breeding and hybridization by which Renaissance horticulturalists transformed simple wildflowers into elaborate multicolored blooms. She is suspicious of artificial interventions into nature; for her, Great Creating Nature is a goddess like the Gaia of our own environmental philosophers. There is perhaps a further unconscious thought lurking in her mind. She has just been anxiously worrying about her own presumption in entertaining the amorous advances of a prince, whose blood and breeding are so far above what she imagines to be her own humble origins. She is embarrassed about the fine clothes she is wearing for the feast, and about the rustic garments that her lover Florizel has taken on in order to woo her without revealing his princely identity. Nature and human art should not mix, nor should commoners and nobility; if they do, appearances become deceptive and things will not be as they seem. Perdita is innocent, straightforward, and honest, and dislikes adulteration and deceit. Her decision not to cultivate the carnations and gillyvors is based on a personal code of sincerity:

PERDITA I'll not put
The dibble in earth, to set one slip of them;
No more than were I painted, I would wish
This youth to say 'twere well, and only therefore
Desire to breed by me.

Perdita dislikes the hybrid flowers because they use their attractive looks to gain the advantage of being reproduced, instead of their more modest sisters. It is as if she were to paint herself with cosmetics in order to make Florizel cultivate her with *his* “dibble” (garden trowel). But there are wider implications still. For if Perdita is right, art itself is a profoundly questionable enterprise. The very art of drama in which she is portrayed is a fiction. An actor is playing her part—in Elizabethan times, that actor would have been a gifted prepubescent boy, and so the whole enterprise is fraught with

dissimulation. And what is art? For Shakespeare the word had an enormous range of related meanings, which had not disentangled themselves from each other. It could mean “art” in the contemporary sense of what we find in an art gallery, a book of poetry, a symphony hall, or a theater. But it was also a normal term for skill or technique, and by extension for technology, machinery, and mechanical devices of all kinds; and it also meant magic, alchemy, and the mystical sciences of astrology and prognostication. It could be a humanistic discipline, as in “liberal arts.” It could also mean deceptive practice or cunning imposture.

The ambivalence and complexity implicit in Perdita’s use of the term are surely quite familiar in our own times. At present we are struggling with the ethical and health implications of the science of genetic engineering by means of recombinant DNA. Should we buy the new genetically-altered tomatoes on the grocery shelves, or drink the milk produced with the aid of bovine hormones? What about the strawberries with their chimeric pesticide genes, the experimental fruit flies with eyes growing out of their legs and antennae, or the patented strains of cancerous mice? We must balance the benefits of insulin, thyroid hormones, oil spill-eating bacteria, interferon and gene-grown taxol against the specter of laboratory killer viruses; gene therapy for inherited diseases against sinister eugenic schemes to improve the human gene pool; in-vitro fertilization and implantation against the legal and kinship dilemmas that result when the birth mother is not the same as the genetic mother. And, of course, there is the biggest art of all: terraforming or geo-engineering.

Reading Shakespeare, we become aware that our problems are not new; Perdita’s unease prefigures ours. Indeed, since the Neolithic agricultural revolution, when we first began selecting plants and animals to breed future stock, we have been in the business of genetic engineering and recombinant DNA. Our humblest domestic and culinary techniques are just as “unnatural” as the activities of the biochemists. Brewer’s yeast, sourdough, ginger ale plants and cheese-mites are all out-and-out examples of human tinkering with natural genetic processes. When we divide a clump of irises in the garden we are literally practicing clone technology; when we enter a pedigree dog or cat or pigeon in a show we are practicing eugenics on an entire species. Worse still, when we choose what we believe to be an exceptionally kind, intelligent, attractive, healthy and honest person to be our mate and bear or sire our children, we are engaged in human eugenics on our own local scale. There is no escape.

Thus, Perdita cannot evade the fact that as a tool-using animal—the “dibble” she uses for gardening is a cunning little technological device—she must alter nature in order to survive. She needs “art” in its technological sense. Likewise, as a social, role-performing animal she must put on appearances—her festive party dress—in order to coexist with other humans (the theatrical sense of “art”).

How may this contradiction between nature and art be resolved? Polixenes' reply to Perdita reveals a wisdom that we could do well to take to heart. Recall that she has just disparaged the gillyvors on the grounds that there is an art that went into their ancestry.

POLIXENES Say there be;
Yet Nature is made better by no mean
But Nature makes that mean; so over that art
Which you say adds to Nature, is an art
That Nature makes. You see, sweet maid, we marry
A gentler scion to the wildest stock,
And make conceive a bark of baser kind
By bud of nobler race. This is an art
Which does mend Nature, change it rather; but
The art itself is Nature.
(IV.iv.88)

The image that Polixenes uses to explain the relationship between nature and art (or rather, perhaps, between potentially artful nature and fundamentally natural art) is the horticultural technology of grafting. This is what he means when he speaks of marrying a “gentler scion to the wildest stock.” A gardener or vineyard-tender will cut off the upper stem of a vigorous wild plant, and bind to the stock that remains the stem and upper branches of a more delicate hybrid plant. Nature is accommodating enough to allow the graft to “take,” and the two plants are fused into one. The resulting combination has the virtues of both—the resistance to disease, pests, and frost of the wild stock, and the hybrid’s desired characteristics of productiveness, excellence of fruit or flower, or perfume. “A bark of baser kind” (the wild stock or root) is made to “conceive” (become pregnant) by a “bud of nobler race” (the hybrid cultivar). The Elizabethan word “conceive” had for them as for us the further meaning “to engender a new idea,” so Shakespeare is also suggesting that there is a natural continuity between the miracle of sexual fertility and the even greater miracle of imaginative creativity.

The main point of Polixenes’ remarks is that the art of genetic engineering by which we improve nature, or even change it, was itself created by nature. The plain ancestral gillyvors have the genetic potential to produce the gaudy streaks that attract the eyes of men and women, and persuade human gardeners to propagate them. Humans become a way for streaked gillyvors to make more streaked gillyvors, to extend the diversity of the gillyvor species by branching out a new breed specially adapted to the environment of human culture. The gillyvor is by nature an art-using plant. And we humans are by nature art-using animals. We survived to reproduce because we had the capacity to make tools like sheep-hooks or dibbles, and to breed domestic species like sheep or gillyvors for our own purposes. Moreover, our capacity to make fictions—to tell lies and put on disguises and mount plays and enhance our looks by clothing or cosmetics—is likewise a natural talent, like the eagle’s to fly or the mole’s to

dig. It is of a piece with our ability to express our thoughts in words, and to build families, tribes, cities, and nations.

It is also the foundation of all economic activity. Human art, human fiction, human invention, human technology, are not unnatural forces that have suddenly erupted into nature, but are the natural continuation of nature's own evolutionary process. Since they are natural productive forces in their own right, they participate in nature's own mysterious capacity to grow and reproduce. Furthermore, human economic production cannot be separated from human reproduction; the family is still the primary unit of economic cooperation, and marriage is the major means of distributing the wealth that accrues to production.

Perdita's hard-and-fast distinction between sterile insincere art and creative honest nature will not hold up. Nature will accept the graft of the wild and the artificial: nature can be artistic, art can be natural. There is nothing wrong in themselves with fictions, contrivances, and masks, nor are such things unique to human society: the gillyvors mask themselves in order to be cultivated.

So the issue has changed profoundly. It is no longer a matter of having to choose between the innocent creative sincerity of nature and the sophisticated sterile deceptions of art—a choice in which we would be forced to abandon all the advantages of technology, consciousness, language, and social communication if we were to opt for moral purity. Art and nature are one: we must now use our moral and aesthetic judgment to choose between courses of action, not some simple formula that labels one artificial and the other natural. The past course of nature as we can discern it in the evolution of plants, animals, and humans—and even, today, in the cosmos of physics and chemistry—can act as a suggestive and potent guide in making such decisions. But the decision we make will itself be part of nature, and it will take its place beside other natural events, both beneficial and destructive. When we choose to alter nature by a technological intervention, or when we choose to alter society by some new fiction, we should do so with the whole tradition of natural evolution in mind. But we cannot abdicate the prerogative of choice itself that nature has endowed us with.

In the centuries since Shakespeare, we have seen one side or other of this argument take precedence. The Enlightenment tended to reduce the world to a classical mechanical system of cause and effect: the world is mechanistic clockwork, animals are robots, and human beings are only other than physical robots if they are inhabited by a ghost of pure reason—a ghost, since reason gives only one answer to any question, that is itself deterministic.

The romantic reaction—against the dark satanic mills of Blake and against the atomism Blake derided in Voltaire and Rousseau (and by implication, Newton)—came next. Natural spirits were excavated from the dustbin of history and restored as creative and energizing forces. Civilized life was critiqued as inauthentic. There was a profound refusal to take responsibility for nature (a refusal that Goethe in turn rejected in *Faust*).

And then there was the modernist reaction to the romantic reaction: the heroic futurism, the formation of totalitarian solidarities of class, race, nation, culture, gender, and religion, identity politics, and the instrumentalist view of human and natural life.

We are now entering a period in which the wisdom of Shakespeare's renaissance formulation may once more be possible. The new sciences of interdependence, systems, emergence, coevolution, nonlinear dynamics, modeling, and whole-to-part logics, like quantum computation and Boolean mathematics, promise kinds of understanding that may once more be called "arts." Such sciences

- a. Don't simply crush nature
- b. Don't attempt to withdraw from it
- c. Don't attempt to submit to it
- d. Do try to understand it as it understands itself, to lead it, guide it, tweak, garden, cultivate, protect, breed, and provide a nervous system for it.

Science fiction is the major instrument by which such further thinking has been done and is still being done. This has taken place by means of an unexpected revival of the genre of epic. I have argued in my 2012 book *Epic: Form, Content, and History* that epic is humanity's common story of how we became human in the first place: our account of our evolutionary emergence from the inside, handed down by unforgettable narrative memes over the millennia, and adapted to the present needs of the society in which it is recomposed. As the responsibility for taking care of our planet and our solar system is forced upon us, we have begun to revisit the epic techniques by which we think through what our actions should be. They are world- and city-creation, extrapolation—the construction of narrative trees of decision and the scenarios that might emerge from them—and imaginative immersion.

Science fiction also offers a diagnostic tool for the whole realm of cultural zeitgeist, poetics, and myth, that we are embroiled in at this moment in history. Science fiction sensitively tracks our cultural moods, problems and opportunities.

The pervasive sense of disappointment and betrayal felt by the more adventurous members of western societies at the abandonment of a serious space program seem to lead from the optimism of Heinlein on the right and Asimov on the left to the exciting but deeply pessimistic dystopias of cyberpunk. Instead of the Sputnik boost to education, which really energized the economy, we got the war on poverty, which everybody came to feel was a failure: instead of Mars we got Vietnam and other demoralizing and unheroic wars with third world countries. The State could no longer be trusted to inspire us. The hugely successful *Hunger Games* books and movies were, I believe, one indicator or symptom of the collapse of cultural hope that produced the Occupy movement, the Tea Party, Black Lives Matter, Trump, America First, MeToo, and the white opioid crisis. Like rats trapped in a cellar with no exit, we turn on each other and ourselves, or seek out scapegoats when what we need is space.

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The argument that a space program was too expensive when there were urgent social problems to be solved is based on an economic misconception. One of the things a healthy economy needs is an attractive sink of value, some really big activities that suck money at high velocity through the system and empower ideas and work. The most successful continuous society on earth was that of Egypt, which for thousands of years poured money endlessly into vast tombs and monuments. Europe created the Renaissance out of the economic explosion fired by its own expensive “space program,” the building of the great cathedrals. What saved America from the Great Depression was the enormous expense of World War II. It’s not money that counts, it’s the velocity of money and the pervasiveness of its flow. The Great Society might not have been needed if we had been spending billions and hiring millions of people to put humans on Mars. We slumped in the seventies because we did not have enough things to spend money on, as evidenced by the spike in inflation.

Allow me to articulate in mythic terms some of the themes that a fiction writer senses today under the surface of the news. Trapped on this planet, enterprising young males and newly-emancipated females had no worlds to conquer, no frontier territories to light out to, no enemies that were worth fighting without destroying the whole world. We have divided ourselves into increasingly balkanized identity groups, in order to find suitable villains for our steel. At the same time our ideological prohibitions against playing God forbade us from taking on the heroic task of rebuilding and healing our own planet, and carrying life out into other worlds. Instead we were enjoined to limit, humiliate, and stifle ourselves, our children, and our imaginations to propitiate the ghost of the ancient deities that once flooded the world, and who promised with the rainbow not to do it again. Deities can of course rescind promises if they feel like it, and it is beginning to look as if that is what they are about to do. Some of us refuse to believe it, others do believe it and wish to punish and sacrifice themselves and others on the psychological pyramid-altars of political virtue. Guilt and despair tell us that the one thing we must not do is simply fix the problem; we would rather obey and be punished by the Parent than grow up and become parents ourselves.

Epic offers stories that articulate the great tragi-comic drama of human responsibility. The oldest one of all, *Gilgamesh*, begins with two episodes that directly confront the relationship of humans with the rest of nature. The first is the transformation of the beast-man Enkidu into a conscious language-using mortal human being—a story adapted in the

Book of Genesis to illustrate the Fall of Man from innocent idiotic immortality into a thinking historical actor. The erstwhile natural man then challenges the tyrant Gilgamesh and teaches him humility, decency, and friendship. The second episode is the great expedition of the two heroes to defeat the nature-god Humbaba, cut down the cedar-forest of Lebanon, and use the wood to build the city of Uruk. The poem explicitly recognizes the beauty and spiritual aura of the forest and its god, and recognizes the pathos of Humbaba's defeat, but also celebrates the glory and spiritual significance of the city that emerges and the heritage it establishes. We swap a sterile immortality for all the open-ended creativity of time. You cannot make an omelet without breaking eggs.

In the *Odyssey*, Odysseus must defeat the nature-god Polyphemus to become his true self and earn his name (which means "Trouble" in Greek). But it is not a simple victory: he must leave Polyphemus alive so that he can roll away the great stone that locks Odysseus and his men in the monster's cave, and Odysseus must pretend to be an animal in order to escape. We need nature to transcend the rest of nature, and transcendence does not mean eradication but responsibility.

We see the same patterns in epics all over the world—in the Mayan *Popol Vuh*, in the Persian *Shahnameh*, in the Chinese *Journey to the West* in which a redeemed beast-man helps rescue the sacred writings of the Buddha. It's in the Icelandic saga of the Volsungs, in the Korean epic of Jumong, in the African epic of Mwindo, told by the Nyanga people of the Congo, and in the Indian *Mahabharata*. All epics are about a great journey, a quest, that recalls our amazing walk around the globe, our colonization of the shores of the Mediterranean and the wilds of the Himalayas. These are the early science fictions of our species, the fictionalized story of our own evolution as a species from our own roots in nature.

And now we see the ideas developed in the science fiction of the last two hundred years, from Shelley, Verne and Wells through Burroughs, Heinlein, Asimov and Stapledon, to Leguin, Banks, Bujold, Cherryh, Bear, Brin, Benford, Robinson, and other contemporary SF giants.

My own three epic poems take up the same themes. The two most recent, *Genesis* and *Apocalypse*, deal respectively with the terraforming of Mars and the geo-engineering of the Earth to reverse global warming. Both use natural processes—bacteria adapted to survive on Mars, and massive plankton blooms in the southern oceans—as the new agriculture of a new Neolithic. Both envisage a different kind of city, that is the flower and fruit of nature, not its defeat. Both acknowledge the tragedy inherent in any change of our condition, and the condition of our biosphere, even when the change is for the better. Both attempt to define what we might mean by "better" in the first place. Is it our mission to be the bees and birds of a new pollination and seeding of our local piece of the universe, as it was that of the ocean-dwellers that crawled onto the land half a billion years ago? A