

YEAR MILLION

Science at the Far Edge of Knowledge

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Introduction

My own view is that we will successfully negotiate the hazards threatening our species. We will not kill ourselves off. We will not die off from disease. We will wax and wane with all manner of climate changes, asteroid impacts, runaway technology, and evil robots. We will persevere . . . perhaps this view that we are unkillable—at least as a species—is naive. But even if we are to live as long as an average *mammalian* species—between 1 and 3 million years—we still have huge stretches of time left, for our species is barely a quarter of a million years old. And who says we are average? My bet is that we will stick around until the very end of planetary habitability for this already old Earth.

Peter Ward, *Future Evolution:
An Illuminated History of Life to Come* ^[1]

A million years—it's a haunting number, quite terrifying if you put your imagination to work trying to grasp what it means, what it implies.

Casting our minds a million years into the past, we find in the wide world no trace anywhere of familiar, comforting intelligence. Yes, there are scattered hominids, *Homo antecessor*, *Homo heidelbergensis*, our ancient precursors—but perhaps they have only rudimentary speech and song, few tools, little in the way of clothing (although at least they own fire to warm them in the night), maybe no shelter from

the rain and snow other than huddling beneath bushes or in caves as lightning cracks the sky. We imagine our first true ancestors to have been nasty, brutish and, if not short, then certainly short-lived. It is eerie to consider that these protohumans were not entirely alone, as we are; for they shared their planet with equally brutish cousins—*Homo erectus*, *Homo ergaster*, others—who separated from common ancestors a quarter of a million years earlier.

In our future, we can anticipate a further splitting of our hereditary line, but on a vaster and stranger scale. A million years hence, if any of our lineage survive, they will be very different from how we are today, far more alien to us than we are to early *Homo*.

Is there any way to get a sense of those pitiless gulfs of time, a million years echoing away to either side of us? Not really, not to any degree that our local, earthbound imagination may easily capture, as we handily grasp the size of a football field or a cup of water or a skyscraper or an ant or a decade or the time remaining to shop for Christmas. We can try, though, by analogy:

You stand on a long, empty highway, left arm clasping the right hand of the person beside you, your mother or father, fingers interlaced, he or she in turn linking you to a grandparent, and on, and on, each pair of arms marking out one meter of the ground stood upon (call it a yard if you remain uneasy with the metric system). Why, then, four of you can represent a century of time. That's because roughly twenty-five years comprises a generation—the average time it takes from birth to maturity and reproduction, baby to parent. So one thousand years is forty generations, forty people linking their hands, left in right, right in left, marking out forty meters of the Earth's surface.

By the standard of ordinary experience and memory, one thousand years is a great period of time. Within a millen-

nium, nations and empires rise and fall, tongues mutate into incomprehensibility. (Have you tried reading Old English from 1000 CE? *Beowulf*, say? Not even all the letters are the same.) Multiply that span a further thousandfold and the impact becomes overwhelming.

Now, rather than the forty people linked in a chain as long as a city block, 40,000 people extend along the highway, forty kilometers of them—twenty-five miles—much farther than the eye can see. To walk in a single day from end to end of this stretched-out township would take more endurance than most of us could muster. Yet if this linear daisy chain were composed of generations of our ancestors, we could reach the dawn of human prehistory in less than a single kilometer. Back and back in time from that point we'd trudge, our hand-clasped predecessors growing less and less familiar in appearance and behavior with every kilometer; in truth, less and less human.

That's the million years of humans and hominids stretching to our left. Extend it to the right by a further thousandfold to a billion years (if that were possible, if the Sun were not fated to burn away the skin of the world first) and the generations will stand hand-in-hand, by an uncanny coincidence, all the way around the equator.

Unless we exterminate ourselves very soon, and much of the planet with us, by global heating, by pandemics—natural or engineered—spread by world-girdling travelers and freight, by the undissipated threat of thermonuclear war and other dreadful weapons, then there's no reason to suppose that the next million years will witness any less change than the first million.

If anything, as proved by the accelerating rates of change during the last couple of centuries and especially the last few decades, the future will be far stranger and more devious than the past. If the gulf of time and difference between us

and our remote ancestors seems impossible to comprehend, then imagine the chasm dividing us from our descendants. This prospect includes a technologically driven Singularity, an exponentially rising curve of drastic change that promises (or threatens) to turn our kind from mortal humans to deathless posthumans. If so, can any attempt to envisage our descendants a million years hence, let alone a billion, be other than futile? Here is a vista that can seize the imagination and wring it dry, capture the heart and fill it with yearning or horror.

This book is a voyage of exploration into that barely conceivable distant future, into a time so remote that we cannot even be certain how many generations extending to the right will be required to get there. For one thing, it is not written in stone or immutable DNA that there must be four generations per century rather than one per millennium. Already, ambitious experts in gerontology—the science of aging and senescence, of our so-far-fated fall into death—are exploring ways to extend the typical life span of healthy, vigorous humans. When they succeed (for, however long it takes, it is certain that they shall succeed, since the human body is an immensely complex machine capable of repairing its own code, otherwise each baby would be born old), generations shall surely arrive more slowly, or the world would soon be choked to death with clamoring human mouths and stomachs.

So it might be that within a further century the first child will be born with the prospect of a millennium of robust life stretching before her. In this case, rather than forty thousand consecutive generations stretching to the Year Million, perhaps we shall see only one thousand or fewer. If that spoils the analogy, so much the better, since a long rich life is preferable to a short mean one, or even a short full one. Still, a mere thousand generations of our

own history carries us back most of the way to the dawn of true humankind. Can we even start to conceive what the people of the Year Million might be like, supposing that our lineage does not first destroy itself or spill outward to the stars, or change into “intellects vast and cool and unsympathetic”?

This resonant and disturbing phrase is from the opening paragraph of H.G. Wells’s *The War of the Worlds* (1898), in which Martians invade Victorian England. Wells was at one time, a century or so ago, one of the world’s most famous writers and pundits. Before cultural arbiters decided to split radically imaginative fiction off from literature, Wells invented most of the core ideas that later formed the foundation of what we know as science fiction. But Wells was also a significant science writer, as well as a historian and amateur in economics and political theory.

The Victorians had been obsessed for half a century with promises of new knowledge and technology, which were remaking the planet both for good and ill. Wells became rich and influential not only for his early dazzling fiction but as a great explainer, an Isaac Asimov or Carl Sagan of the turn of the 20th century. He did not hesitate to reach back into the remote evolutionary past (Darwin’s *On the Origin of Species* had established the truth of evolution only forty years earlier) or hurtle forward to the remote future. His great novel *The Time Machine* (1895) plunges a Victorian amateur scientist into the year A.D. 802,701, and then further still, to a dismal epoch thirty million years hence when the rotation of our world has stalled, one face locked forever toward a vast, crimson, dying Sun scarred by dark, tumor-like sunspots, then further yet, nearly to the death of Sun and Earth alike, though a dire creature creeps on tentacles from motionless red sea to shore. That particular future, scientists have reckoned, will never happen.

Within half a billion years' time, the Sun will bloat and blaze ever hotter (unless our progeny modify the very star itself, or Earth's orbit), not quite dissolving the world but blowing the atmosphere into space, evaporating oceans, and melting mountains into slag.

In November 1893, two years before *The Time Machine* astonished the world, Wells, in science-journalistic mode, cast his mind forward a thousand millennia. "The Man of the Year Million" was a choice entertainment for the *Pall Mall Gazette*, a newspaper named for novelist William Thackeray's imaginary journal which had claimed that "We address ourselves to the higher circles of society: we care not to disown it—the *Pall Mall Gazette* is written by gentlemen for gentlemen." Although Wells appears never to have reprinted that early exercise in Darwinist futurology, he self-mockingly incorporated portions, as "Of a Book Unwritten," in *Certain Personal Matters* (1901). That was the year Queen Victoria finally died after her prodigious sixty-three-year reign, the definitive end of the Victorian era, the first year of the twentieth century. The duration of her reign alone is itself sufficient to boggle the mind. Sixty-three years—how the world would be changed if all rulers remained in office so long! Victoria succeeded to the throne upon her father's death in 1837. Imagine the history of the world had her long span been the standard. Thomas Jefferson, elected president of United States a full century before Victoria died, might then give way in 1864 to Abraham Lincoln. Were he not fated to die a year later, after the ruinous Civil War, then Lincoln would preside until his replacement in 1927, rather improbably, by Calvin Coolidge, who would see the world through the Great Depression, World War II, the Cold War, the collapse of the Soviet empire, and on into the early years of the rule

of George H. W. Bush, himself likely to remain in office until the middle of the 21st century. None of this is strictly impossible, although my analogy is naughtily strained: Victoria was crowned at nineteen (and her granddaughter Elizabeth II at twenty-five), hardly a plausible age of succession to the chief office in a republic. Yet if this modest thought experiment with customary time is dazing, how can we possibly imagine humanity in the Year Million?

We can't. It's as simple as that. But we can try to chip at the edges of the idea of deep time, like one of those Stone Age toolmakers 30,000 or 50,000 years ago, mired in an eons-long annual cycle where the only change anyone remembers clearly is the familiar flux of the seasons, the bursting and then fading transformation from infancy through adulthood and then the decline to death.

Suppose we figure the passage of one year in the million-year future history of humankind (and of our successors) as a fleeting hour in a single contemporary lifetime. A million hours is just a little over 114 years. Today we have in our midst a number of supercentenarians; the oldest known human, Jeanne Calment, died at 122. Suppose humankind, as a distinct, articulate species, is sixty thousand years old. Suppose also that this species will last at least a million years from its emergence (most species persist that long before going extinct). Figuring one hour per year, our kind is now merely seven years old, with another one hundred seven years stretching ahead of us. We might find ourselves smiling to remember that at the age of seven, according to traditional doctrine, children reach the age of reason. Perhaps it's no accident that now we struggle with our greatest difficulties yet, and against the greatest odds, toward a world where superstition, impulsive brutality, and willful ignorance dissolve with the first stirrings of global maturity.

Wells jestingly attributes his exploration of the Year Million to a German academician, “one Professor Holzkopf,” or Blockhead, fancied author of *The Necessary Characters of the Man of the Remote Future Deduced from the Existing Stream of Tendency*:

Man, unless the order of the universe has come to an end, will undergo further modification in the future, and at last cease to be man, giving rise to some other type of animated being. At once the fascinating question arises, What will this being be? Let us consider for a little the plastic influences at work upon our species.

It is the key question that this book, too, will explore.

Drawing upon a rather heavy-handed Darwinism (or maybe Social Darwinism, its debased cousin), Professor Blockhead deduces certain attributes that will likely mark the man (and the woman, too, presumably) of that distant age. Freed up by machines from the urgencies and demands of labor, our offspring will grow physically feeble. Blockhead continues, “One needs wits now to live, and physical activity is a drug, a snare even; it seeks artificial outlets, and overflows in games. Athleticism takes up time and cripples a man in his competitive examinations, and in business. So is your fleshly man handicapped against his subtler brother.” We laugh in disbelief at this failure to predict the narcissistic culture of the gym, of dieting, of running and swimming and skiing for health and the sheer fun of it. But is Wells entirely wrong? The athletic, Professor Blockhead asserts, “is unsuccessful in life, does not marry. The better adapted survive.” Ridiculous? Is it true that many of those who preen before the mirrors, male and female alike, delay families or forego them altogether? Probably not—certainly no more so than the lazy, the

harried, the much-mocked nerds whose focused mental work underpins so much of the wealth of our culture. On the other hand, Wells (or Blockhead) is trying to discern a long, long trajectory created by evolutionary pressures, the sort that shaped crabs with one enormous pincer and leopards with spots they can't change.

As a shirtsleeve intellectual, Wells foresaw the connection between intelligence, productively and profitably used, and sexual success in the post-Victorian world. If he failed to see a rise of a battalion of shy and socially incompetent nerds, perhaps that's because he was himself a nerd with a large sexual appetite and unusual success in satisfying it. In any event, Wells (or rather, Blockhead) imagined the forces of evolutionary adaptation slowly but inexorably modifying human inheritance toward the "Man of the Year Million": absorbing nutrients directly through the skin, legs withered but the manipulative hand with its sensitive fingers and thumb grown grotesquely large, the brain swollen inside its immense skull even as the Sun itself, outside their habitat domes, swells and reddens.

Incredibly, at first Wells seems to be sketching the creature popular mythology calls the Gray—the supposed alien pilot of flying saucers.

Eyes large, lustrous, beautiful, soulful; above them, no longer separated by rugged brow ridges, is the top of the head, a glistening, hairless dome, terete [round and tapering] and beautiful; no craggy nose rises to disturb by its unmeaning shadows the symmetry of that calm face, no vestigial ears project; the mouth is a small, perfectly round aperture, toothless and gumless, jawless, unanimal, no futile emotions disturbing its roundness as it lies, like the harvest moon or the evening star, in the wide firmament of face.

But these brainiacs of the deep future are even stranger than the Grays of UFO abduction legend (which might conceivably be based on Wells' image). See them on their home ground, in the Year Million:

There grows upon the impatient imagination a building, a dome of crystal, across the translucent surface of which flushes of the most glorious and pure prismatic colors pass and fade and change. In the center of this transparent chameleon-tinted dome is a circular white marble basin filled with some clear, mobile, amber liquid, and in this plunge and float strange beings. Are they birds?

They are the descendants of man—at dinner. Watch them as they hop on their hands . . . about the pure white marble floor. Great hands they have, enormous brains, soft, liquid, soulful eyes. Their whole muscular system, their legs, their abdomens, are shriveled to nothing, a dangling, degraded pendant to their minds.

This strikes us today as an absurd, comical image of tomorrow's humanity, and probably, on reflection, it struck Wells that way, too; otherwise, why attribute this homespun evolutionary prospect to Professor Blockhead? Even so, it's hard to deny the appeal of his question, as we might rephrase it slightly today:

Unless our corner of the universe changes out of all recognition, our species, our stock—the kind of human person we know—will certainly undergo further modification in the future, as it has in the past, and at last cease to be human (at least as we understand the term), giving rise to some other type of consciousness. So again we face the fascinating

question: What will this person be like, in the Year Million and beyond, as the universe expands ever more swiftly into the darkness of space and time?

Wells himself, once so confident of the future, offers a grim prophecy: “In the case of every other predominant animal the world has ever seen . . . the hour of its complete ascendancy has been the eve of its entire overthrow.” A century or so later, that warning seems only more urgent and plausible. Anxious voices tell us that humankind is a kind of terminal pollution or plague upon the face of our blue world, as we destroy other species and the natural environment and slaughter our fellow humans by the hundred, the thousand, the million. Others, more optimistic (on happy days, I’m one of them), see in the gorgeous flowering of science in the last four hundred years proof that we are here for the long haul, extending and deepening our knowledge of the world and of ourselves. This book explores both possibilities, and more besides.

It is conceivable, now that we have learned that three-quarters and more of the universe remains invisible to us (its dark matter and dark energy), that consciousness will never go down under the attrition of entropy and exhaustion. Already we have hints that the universe we see is the merest fraction of its true extent, both in space and time, that the awesome ignition of our cosmos in the Big Bang might have been a bubble blown from another universe, and another before and beside that one, all the way down into the brilliance of eternity. It is not impossible that this universe is the deliberate or accidental byproduct of some colossal experiment performed in the universe preceding our own, just as scientists have conjectured means by which humans or posthumans of the future might open up en-

tirely new universes through the creation or encoding of black holes.

Three decades after Wells' half-serious–half-facetious glimpse of the Year Million, the great British philosopher and visionary Olaf Stapledon presented an even more vertiginous cavalcade of deep time: *Last and First Men* (1930), followed seven years later by perhaps the ultimate portrait of life in the cosmos, *Star Maker*. These books are often shelved as fiction, as novels, but they have nothing in them we recognize by that description beyond the fact that their very worlds and histories are invented. Really, they are essays in projecting human understanding beyond its own limitations, from Stapledon's own frightening immediate future (the rise of Nazi Germany and the Soviet Union) through the multimillion-year sweep of human and genetically modified posthuman evolution in an increasingly reconstructed solar system, and finally to a history of those immense consciousnesses we call stars and galaxies.

The available cosmology and physics of the 1930s was hardly more developed than the sciences upon which Wells drew, yet Stapledon's reasoned dream of deep time has not yet been surpassed. It can be seen framing the essays in this book, which are themselves created by a select group of expert dreamers, chosen for their insight and knowledge, who convey to the rest of us what lies ahead of our species in the long, long voyage to the Year Million and beyond.

Is such voyaging nothing better than a disinclination to grapple with the pressing problems of today, a kind of mind candy? I don't think so. As Stapledon put it at the outset of his great journey:

To romance of the future may seem to be indulgence
in ungoverned speculation for the sake of the marvel-

ous. Yet controlled imagination in this sphere can be a very valuable exercise for minds bewildered about the present and its potentialities. Today we should welcome, and even study, every serious attempt to envisage the future of our race; not merely in order to grasp the very diverse and often tragic possibilities that confront us, but also that we may familiarize ourselves with the certainty that many of our most cherished ideals would seem puerile to more developed minds. To romance of the far future, then, is to attempt to see the human race in its cosmic setting, and to mould our hearts to entertain new values.

And if that seems rather too solemn, a touch schoolmasterly and officiously profound, then let's not forget that casting ourselves forward in controlled imagination to the deep future is a hell of a lot of *fun*.

In these fourteen specially commissioned glimpses of the future, we range from the slow convulsions and occasional drastic lurches of the earth itself during the next million years to speculative portraits of the profoundly deep future, an era not just remoter from the Year Million than that fabled year is from the twenty-first century, but perhaps millions of times further away than we stand already from the Big Bang. We shall not restrict our gaze solely to our titular Year Million, but regard it instead as the emblem of an impossibly remote future in which humankind, or its offspring, might not only thrive but prevail, perhaps rewriting or rewiring the universe itself. This optimism is not shared by all our writers. Zoologist Dougal Dixon, who charts the vicissitudes likely to afflict our planet in the next thousand millennia, has speculated bleakly in his

wonderfully illustrated and imaginative book *After Man: A Zoology of the Future*:

Ultimately the Earth could no longer supply the raw material needed for man's agriculture, industry or medicine, and as shortage of supply caused the complex and interlocking social and technological edifices crumbled. Man, no longer able to adapt, rushed uncontrollably to his inevitable extinction.^[2]

That dire prospect remains extreme, but not impossible, as the planet's climate shifts before our gaze and threats of catastrophic global conflict continue to turn our dreams of the future into nightmares, especially with the unprecedented risks of global pandemic and new potentially lethal technologies. But apocalyptic forecasts do not speak of the inevitable, because we have choices. We are, so far, the only creatures of Earth who live forward and backward in time, in recollection and imagination. We can make plans, and while we might bring doom upon ourselves, we also hold in our clever hands and brains and passionate hearts the tools of our survival and thriving.

If our descendants do make it to the Year Million, we might hope that they share at least some of our values, some of our joy. Will they still beget children in that far-off epoch? Will they laugh at silly jokes, get drunk, stay late to work, either grumbling or driven by obsessive interest in the task at hand? Can we expect Shakespeare and Ravel to survive in their memory? Will they count in tens or twos, or leave all that to their machines? Jim Holt, a science journalist who writes frequently for the *New Yorker*, suspects that in the contest of survival between mathematics and mirth, the people of the Year Million might find a surprising

winner.

All this great passage to the Year Million and beyond will be conducted under the baton of Darwin, for evolution by natural selection (including, most definitely, sexual selection) remains the great winnowing sieve, the pitiless shears that shape all life and indeed much of culture. Physician Steven Harris, in a magisterial and exciting essay in the natural history of the future, traces some of the forces that will influence humankind's deep future.

It is often supposed by romantics that our destiny lies far from the planet Earth, an exultant and sometimes crassly imperialistic vision of a sky filled not just by remote stars but with the babbling voices of our trillion trillion children. If Earth is not destroyed soon by our own actions and the vicissitudes of nature, it really does seem plausible that our curious, exploratory nature, and the promise of riches hiding in the void, will drive and draw people into space, no matter the cost. In five essays that trace a kind of escalation of tomorrow's voyages, we look at the prospects of humanity and posthumanity in deep space through time.

Harvard-Smithsonian astrophysicist and planetary scientist Lisa Kaltenegger opens the sky to our gaze, looking at the wonderful bestiary of extrasolar worlds discovered in the last few years. Most of those have been apparently inhospitable to life, and startlingly unexpected in character (blazing-hot gas giants orbiting fast around their stars, unlike the cool, slow, majestic giants of our own solar system, Jupiter and Saturn), but they are not necessarily representative specimens. The limitations of current search methods mean that these are just the worlds most easily detected. Our understanding will improve drastically, Kaltenegger explains, when space scientists of the near future cast into the vacuum first hundreds and then thousands and then tens of thousands of satellite telescopes. By the Year Million,

the entire solar system will constitute a kind of colossal eye able to examine the surface of planets Earthlike and otherwise, light years away.

Mathematician, quantum theorist and novelist Catherine Asaro is not prepared just to *look* at those worlds; she wants to go there, and suggests that perhaps relativity theory's celebrated prohibition of speeds faster than light might not be absolute after all. But even if it proves to be, elementary arithmetic makes it clear that within a million years we could, in principle, colonize the entire Milky Way galaxy. Wil McCarthy, a rocket engineer, writer, and innovative researcher in "programmable matter," wonders what life would be like for a citizen of that galaxy. Robert Bradbury, a polymath equally at home in computer programming, advanced genomics, and nanotechnology, ponders a galactic future in which entire solar systems—starting with our own—are stripped of their planets to build what he has called "Matrioshka brains." Within these immense Sun-orbiting swarms might dwell, by the Year Million, untold trillions of human minds, no longer embodied in bone and protein, cavorting in vastly accelerated virtual realities. Perhaps, though, this radical prospect will not be the form that evolution finds most enduring. Long ago, we went out of Africa into the world; venturing into space, in economist Robin Hanson's analysis, we might begin a wave of ferociously driven outward migration, from one star oasis to the next to the very edge of the galaxy, perhaps leaving behind a blighted wasteland of exhausted worlds.

In such futures, what might be the place of the human mind, of consciousness? Novelist Pamela Sargent and engineer Anne Corwin consider the prospects for drastically increased, healthful longevity, a factor that will change almost everything in human experience. Technology journalist, inventor and aerospace engineer Amara Angelica

sees the Internet expanding on a cosmic scale into the Universenet. Mathematician and transrealist Rudy Rucker sports playfully in an astonishing alternative possible future, where machines have been discarded, replaced by life and mind seeping into everything around us, down to the level of atoms and perhaps deeper. It is a vision so audacious that it seems like a wild joke. But how would our Pleistocene ancestors have regarded a prophetic glimpse of people gazing into a flat screen bright with images of distant places or strange squiggles, hammering with their fingers at a notched board, or speaking into the air as the squiggles dance responsively?

Finally, taking our exploration far beyond the Year Million, to the ends of the expanding universe, across the river of time and into the branches of an endlessly exfoliating multiverse, astrophysicist and novelist Gregory Benford, cosmologist Sean Carroll, and visionary writer George Zebrowski peer into the very deepest future. What they find might seem disheartening—a cosmos evaporating and corroding even as its parts fling themselves so far asunder that they can no longer detect each other. Yet this aching, distant void need not be the end of the story of creation, of the narrative of humankind and our children. Perhaps a trillion years beyond the Year Million, or sooner, we will be building new universes, finding our way across the boundaries of spacetime into realms of which, today, we can only dream and yearn.