Chapter 1

Gigantic Follies? Human Exploration and the Space Age in Long-term Historical Perspective

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In 1667, the poet John Milton, in the final quatrain of *Paradise Lost* reflected upon the exodus of Adam and Eve from the garden of eden. As a believing Christian, Milton understood the biblical story as truth, and thus as the original human voyage of exploration:

> *The world was all before them, where to choose*
> *Their place of rest, and Providence their guide:*
> *They hand in hand, with wand'ring steps and slow,*
> *Through Eden took their solitary way.*

Since the first humans trod this Earth, perhaps 10,000 generations ago, slow wandering steps have formed a characteristic part of the experience of most peoples at one time or another, and for some, migration and exploration has stood at the center of their experience of life. In recent years, wandering and exploration rarely involved literal human steps, but rather technologically sophisticated and organizationally complex efforts to take giant leaps.

My aim in this chapter is to place the whole endeavor of the Space Age into a global historical context. My friend and fellow historian, Felipe Fernandez-Armesto, in his recent book entitled *Pathfinders: A Global History of Exploration*, refers to space exploration as a "gigantic folly."[1] He could be right, but it is too soon to be sure. Folly or not, we can be sure space exploration is consonant with the deepest traditions of our species.

In the pages that follow, I will try to show just how deeply rooted exploration is in human society and will speculate on why that should be so. I will also reflect on some of the global-scale changes since the dawn of the Space Age in 1957, and where space exploration fits in this contemporary history.

1. Felipe Fernandez-Armesto, *Pathfinders: A Global History of Exploration* (New York, NY: Norton, 2006), p. 399.

THE REAL GREAT AGE OF EXPLORATION

When I was a schoolboy in Chicago—early in the Space Age—I defied the odds by studying "The Explorers" five different times between third and tenth grade. Maybe it was the buzz surrounding the Apollo program that inspired my teachers year in and year out to include a unit on Marco Polo, Vasco da Gama, Columbus, Magellan and all the rest, usually ending with Lewis & Clark. I memorized the dates of voyages the way my grandfather as a school boy had memorized scripture. While it didn't do me any harm, later in life I felt misled upon learning that da Gama hired a local pilot in Mombasa (today's Kenya) to take him and his ship to India. He didn't really explore anything: there were already people everywhere he went who gave him directions, as well as provided him and his men with supplies. The same was true of Marco Polo, Columbus, Magellan, and the rest. They were visiting lands unfamiliar to them, and certainly took great risks on the sea, but "explored" only in a generous sense of the word.

The real explorers in human history are almost all unknown, anonymous figures, people who explored unpeopled realms. And the real great age of exploration was long ago and lasted for tens of thousands of years.

Our species, *homo sapiens sapiens*, evolved from various hominid predecessors some time around 250,000 to 150,000 years ago, or so the scanty evidence suggests. This happened in Africa, somewhere between the Ethiopian highlands and the South African high veld. We evolved in ways that made us well-suited to the grassland and parkland ecosystems of East Africa. Among other things, we became excellent long-distance walkers.

After the burst of climate change that occurred at the onset of a glacial period and a period of technological advance in toolmaking, a few bands of humans walked out of Africa, probably around 100,000 years ago. They and their descendants probably skirted the shorelines of the Indian Ocean—now underwater because of deglaciation and sea level rise in the past 15,000 years—where food could be scooped up fairly easily in the intertidal zones. They arrived in India perhaps 70,000 years ago, and in China about 67,000 years ago. People first made it to Australia, which required a maritime voyage even in those days of lower sea level, perhaps 60,000 years ago. Others veered off into Europe about 40,000 years ago and into Siberia some 30,000 years ago. The final frontiers in this long saga of exploration were the Americas (15,000 years ago) and Polynesia (4,000 to 1,000 years ago). New Zealand was the last sizeable piece of habitable land to be discovered, around AD 1000 or maybe 1200.[2]

These peregrinations were real exploration. In some parts of the world, these footloose *Homo sapiens* encountered a few *Homo erectus*, whose ancestors had also walked out of Africa perhaps half a million years back. But those

2. These dates are rough estimates—the older the date the rougher the estimate—subject to revision by a single new archeological find.

Homo erectus did not have language, or at least not much of it, and could not tell *Homo sapiens* much of anything about the lands they were exploring. In any case, *Homo erectus* soon went extinct wherever our ancestors showed up, a disconcerting fact about our family tree. In Europe, the new arrivals encountered Neanderthals and swiftly swept them into the dustbin of prehistory. So for all intents and purposes, these wandering *Homo sapiens* were exploring unpeopled lands, unfamiliar not only to them, but to everyone alive. The trip to Australia must have been especially challenging—across open water and into a new and exotic biological kingdom with almost no familiar plants or animals. Similarly, exploring north into Siberia took much courage: few edible plants, trackless tundra, and bitter cold (the first humans arrived in the middle of the last Ice Age). They needed warm clothes and skill in very-big-game hunting, as well as a full supply of either optimism or desperation.

These Paleolithic pathfinders knew nothing at all about what lay over the horizon, and no one could tell them, yet they went. Had these individuals had the foresight to leave to posterity letters, diaries, journals, and handsome engravings instead of merely the odd flint or chunk of charcoal, their stories would be well-known and their status as historical icons assured.[3]

Motivation and Exploration

Why did they do it? Why leave home at all, why walk out of Africa, why sail to Australia? We can't know, but we can make informed guesses. The last chapter of these great explorations was the Polynesian one, and we know more about that than any of the earlier ones. There are oral traditions, such as those maintained by New Zealand's Maori, as well as much more plentiful archeological remains. Linguistic and genetic evidence adds details to the general picture. The Polynesians clearly organized deliberate voyages of exploration, discovery, and colonization. Presumably, despite their legendary maritime skills, many Polynesian voyages ended badly because the Pacific is a big ocean with only a few specks of habitable land. These voyages were very risky undertakings. People accepted the risk presumably because staying at home seemed worse. In some cases, perhaps, island populations grew too large and starvation loomed, inspiring some to take to the sea in search of fertile land or fish-filled lagoons. Oral traditions suggest that, in other cases, conflicts arose, such as between two claimants to a chieftaincy, and one had to go: their island wasn't big enough for the two of them. If the loser was lucky, his followers

3. Clive Gamble, *Timewalkers* (Cambridge, MA: Harvard University Press, 1994) remains useful on prehistoric migration. See also Steven Mithen, *After the Ice* (Cambridge, MA: Harvard University Press, 2004).

would accompany him over the horizon, perhaps to find a good uninhabited island somewhere, perhaps to find only endless ocean and early death.[4]

The epic Paleolithic peregrinations probably arose more often from conflict than overpopulation. It is hard to imagine the exodus from Africa owing anything to overpopulation: there were probably well under a million people at the time, a number easily sustained on a continent as big as Africa. So why did they move on? Perhaps they were following game animals. Perhaps a wet phase in the Sahara was ending and they had to find a new home. Perhaps they were consistently curious. Perhaps each incremental movement of people arose from different motives. But quite likely conflict was often involved, as among the Polynesians, and the easiest resolution required some group to move away. In some cases, perhaps, cultural conservatives objected to some changes and, like the Puritans who settled in New England, hived off in order to be able to practice their old ways without harassment. Once they got there, they probably often quarreled, split, and the stronger or luckier drove off the unlucky schismatics, as among the Massachusetts Puritans. In other cases, perhaps, cultural radicals pursued new ways that others found distasteful, so, like the Mormons in the mid-19th century, they were driven over the horizon where they, too probably quarreled and split.

Space exploration also arose from conflict.[5] Although the dynamics were very different from what I have claimed about the Puritans, Polynesians, and Paleolithic peoples, it is clear that the funds provided by the Soviet Union and the United States, beginning just over 50 years ago, would not have been allocated without the Cold War context (or some equivalent unprecedented peacetime mobilization of money and resources). The dog Laika, the first living thing to experience Earth orbit, blasted into space aboard Sputnik II just a year after the October 1956 Suez Crisis and the Soviet invasion of Hungary. Gagarin and Glenn were propelled into space by a climate of anxiety fed by the Berlin crisis and the Cuban missile crisis. Americans and Russians did not explore space because they lost a quarrel or feared hunger, but because they feared they might suffer in the Cold War if they allowed space to be dominated by their rival. President Lyndon Johnson feared the communists would drop bombs on America "like kids dropping rocks onto cars from freeway overpasses."[6] In a less colloquial moment, Johnson claimed that, "Failure to master space means

4. Within the sizeable literature on Polynesian history, a good starting point is Patrick Kirch, *On the Road of the Winds: An Archeological History of the Pacific Islands before European Contact* (Berkeley, CA: University of California Press, 2000).

5. Roger D. Launius, "Compelling Rationales for Spaceflight? History and the Search for Relevance." In: Steven J. Dick and Roger D. Launius, eds., *Critical Issues in the History of Spaceflight* (Washington DC: NASA, 2006), pp. 37-70, reviews the American motives for space exploration, emphasizing the political ones.

6. *The Washington Post*, October 2, 2007: A1.

being second best in every aspect, in the crucial area of our Cold War world. In the eyes of the world first in space means first, period; second in space is second in everything."[7] Americans and Russians also found, as many had before them, that virtuoso displays of technological prowess and national resolve served useful propaganda purposes, which seemed especially important during the era of decolonization when the allegiance of billions of people around the world (and their geostrategic resources) was up for grabs. Laika, by the way, lasted four days in space before expiring from heat exhaustion on the 40th anniversary of the Bolshevik Revolution, November 7, 1957.[8]

Space exploration has proved to be a risky venture, although in statistical terms it is probably less so than Polynesian voyaging. Polynesians accepted high levels of risk because they felt they had to: at times, staying put carried unacceptable costs or perhaps even greater risks. Presumably, Paleolithic explorers sometimes arrived at the same calculus. Today, as for the last half century, one of the central questions surrounding space programs is that of risk. How much is prudent to accept when the returns are unmeasurable? Should human lives be risked for uncertain rewards? Although insurance companies and their customers explicitly put monetary values on human lives, and those responsible for air traffic and highway safety do so implicitly, when it comes to space exploration, this calculation is not mainly a matter of money and numbers, but of moral and political positions. For some, the ratio of risk to reward spells gigantic folly; for others, an irresistibly noble calling. Different people, different governments, different eras will hold sharply divergent views on this, and they are probably not easily reconciled or persuaded by mere reason.

In point of historical fact, no human being has ventured beyond low-Earth orbit since 1972.[9] To those in control, the further rewards to distant space travel since then apparently did not justify the risks. Détente, perhaps, diminished the determination behind human space exploration, as did financial difficulties. By the late 1960s, the Soviet economy had begun to flag, and although high oil prices helped prop it up for more than a decade after 1973, the malaise associated with the Brezhnev years did not augur well for renewed commitment to lofty ambitions in space. The American economy (and government revenues) suffered a downturn in 1973 due in large part to high oil prices, raised higher in 1979. So with détente dampening the motives, and economic difficulty undermining the means, ambitions for projects in space waned since the heady early days (c. 1957-1969) when all seemed possible. But, as with Paleolithic and Polynesian

7. Walter A. McDougall, "Technocracy and Statecraft in the Space Age: Toward the History of A Saltation," *American Historical Review* 87 (1982): 1025.

8. This is not the only ironic calendrical coincidence of Cold War space history: the day Sputnik I was launched, October 4, 1957, was the day American TV stations launched that paean to normalcy, "Leave It to Beaver."

9. Launius, "Compelling Rationales," p. 69.

explorers, such reluctance is always provisional. Conditions will change, political resources will ebb and flow, the premium on human safety will evolve. Sooner or later, someone in power somewhere will consider, once again, that the game is worth the candle. Perception of acceptable risk is not merely a calculation of probabilities costs, and benefits; it is also a cultural choice and always subject to reconsideration.

CHALLENGE AND LIBERATION IN EXPLORATION

When humans first left East Africa for the wider world, they experienced both a challenge and a liberation. Their new environments were unlike the ones to which they had been slowly attuned by biological evolution. A lot of their accumulated wisdom presumably applied less well to the shores of the Indian Ocean and its hinterlands than it had to the savannas of East Africa or the Nile valley. However, over time they developed new wisdom appropriate to their new surroundings. They adapted biologically in small ways in accordance with the novel pressures of their new environments, such as gradual variations in skin color to harvest more vitamin D in higher, sun-starved latitudes. In cultural and in biological ways, they met the challenges of migrating into unpeopled realms.

The liberation consisted, in the first part, of escaping the pathogenic load that had evolved among their ancestors. Countless pathogens had had plenty of time to adapt to life within and among hominids in the long haul of evolution in East Africa. Not all of these pathogens, however, made the trip out of Africa. Some could not handle the cooler temperatures of Eurasia. Others, by sheer chance, had not been along for the ride when the migrants left and could not catch up. Thus humans, upon arrival in Asia, entered into a golden age of health that would last some 90,000 years until the transition to agriculture—farming was a great leap backward as far as health was concerned. To judge from skeletal evidence, the first Eurasians suffered much less from infectious diseases than either their ancestors in Africa or their farming descendants. They did not, it seems, live much longer lives: accidents, violence, and abandonment of infants and toddlers kept life expectancy at birth around 30 years. One had to be healthy enough to walk in those days.

The liberation had a second aspect to it. In East Africa, while the foraging and gathering was probably good, the hunting was probably bad. All the big game there had had plenty of time to develop appropriate suspicion of upright, fire-wielding, projectile-throwing creatures, thus limiting the success of hunters. But in Eurasia, and later in Australia, the Americas, and New Zealand, people arrived amid populations of naïve wildlife. Hunting was comparatively easy when the prey took no notice of hunters until they were well within spear-throwing range. The world outside of Africa was a happy hunting ground until selection weeded out the unsuspicious or until the choicest prey grew scarce.

If humans are to leave Earth behind and settle elsewhere in the universe, they will experience something of the same challenges and perhaps the same liberation. They will need to adjust their culture to their new environments, jettisoning all that which was applicable only on Earth and devising new formats appropriate to the far corners of the universe. They will evolve biologically according to the pressures of their new surroundings, whatever those might be. For example, gravity of different strengths from what we have known on Earth would presumably encourage different sorts of bodies. Since migration around the globe led to numerous small biological adaptations in humans over the past 100,000 years (and among other animals as well), it stands to reason that space colonization would transform our bodies, too. Indeed, in short order humans elsewhere in space might cease to be humans. Given the vast distances involved, space colonists would cease to interbreed with Earthbound populations. Only if space colonies were to consist of glorified versions of Biosphere II, hovering in near space, could the biological oneness of humankind be preserved for long.

The biological evolution of space colonists, as with those of us here on Earth, might in time become a matter of conscious design through genetic manipulation more than of natural selection of the sort characteristic of us since time immemorial. The genetic and biological diversification of the creatures formerly known as humans would, it seems likely, grow rapidly in the event of exploration outside our solar system. Should that happen, then even after people colonize space, further space exploration would still be into unpeopled realms, strictly speaking, once people ceased to be people.

Their social and cultural evolution would, of course, also be affected by their distant new environments. The migrants out of Africa kept their basic social organization, the small band of 30 to 80 people who were mostly kinfolk, wherever they went. It seems to have adequately served the purposes of nomadic foragers and hunters, whether in Africa, Australia, or Siberia. Only when people settled down and domesticated plants and animals did they find new social formats (villages, chiefdoms, states) more appropriate. Space settlers, once free of the umbilical cord of Earth, would likewise presumably experiment with new social formats, finding alternatives to those we have known here on Earth.

Thus, in social and cultural terms, one could anticipate a liberation from earthly patterns in the event of space colonization. Whether this would also include counterparts to the epidemiological liberation and the happy hunting ground effect seems much less likely, depending a great deal on what exists out there in the colonized environments. Since hunting provides only the tiniest proportion of the food supply among peoples technologically capable of pursuing space exploration, and because our digestive capabilities are calibrated to the things we eat here on Earth, it seems most unlikely that space colonization would involve an analogue to the happy hunting the first Eurasians, Australians, and Americans enjoyed—even if there is something out there to hunt. Epidemiological liberation is another matter.

At first glance it seems reasonable to suppose that leaving earthly ecosystems behind might allow space travelers and settlers to shed much, if not all, of their pathogenic load. The early emigrants from Africa apparently did so, as did the wandering bands that left Siberia for the Americas around 14,000 years ago, founding the indigenous American populations that were for millennia unusually free from infectious disease.[10] However, it is implausible to suppose that all microbes can be left behind, and once in space microbes may behave differently. A new National Academy of Sciences study claims that certain pathogens, salmonella in particular, prosper better in space than on Earth.[11] Moreover, in all likelihood, the human immune system, like our digestive system calibrated for conditions here on Earth, would prove far less useful elsewhere in the universe. For this reason, if for no other, the health liberation that eased emigration from Africa and assisted settlement of the Americas, would probably not help us make our way in space.

WHAT MATTERED IN HISTORY DURING THE SPACE AGE

This speculation about space, evolution, and who will remain really human threatens to get out of control and become its own gigantic folly. Let me return to a historian's *terra firma* and reflect upon the changes here on Earth since Laika's orbital flight.

In terms of health and demography, this last half century has been the most revolutionary in the human career. In 1957, the average life expectancy was about 47. Today it is close to 67.[12] While we have not been able to "close the book on infectious diseases," as the Surgeon General forecasted in the 1960s,[13] we have intervened dramatically in the relations between pathogens and our bodies. Sanitation, vaccines, antibiotics, and other measures have made a huge difference in human health. Some pathogens, such as the smallpox virus, have been ushered into extinction or near extinction. Many of the crucial developments in this story—the germ theory of disease, sewage treatment, penicillin—date to well before 1957. But their application, their spread around the world, their full effect came mainly after that date. Even though this health revolution remains unevenly distributed around the world, indeed unevenly distributed within many of the world's cities, it probably amounts to the single

10. See Alfred Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (New York, NY: Cambridge University Press, 1987), pp. 197-198.

11. See for example Gillian Young, "Bacterial Virulence: Return of the Spacebugs," *Nature Reviews Microbiology*, 5, no. 11 (November 2007): 833-834.

12. United Nations data appearing in James C. Riley, *Rising Life Expectancy: A Global History* (New York, NY: Cambridge University Press), pp. 37-38.

13. This quotation is variously dated as 1967 or 1969. See J. R. McNeill, *Something New Under the Sun* (New York, Norton, 2000), p. 201.

greatest social change of the last half century. Whether it can be maintained indefinitely is an interesting question that depends chiefly on the ongoing arms race between pathogenic evolution and human efforts at disease control.

One result of the health revolution since 1957 is the global population explosion. The world had about 3 billion people in 1957; today it has more than twice that number. Put another way, it took hundreds of thousands of years for human population to add its first 3 billion, but only 50 years (more like 47 actually) to add the second 3 billion. Whereas for most of human history the annual population growth rate remained well below 0.01 percent, in the 1960s and early 1970s, it briefly attained 2.1 percent per annum. Now it is close to 1.3 percent annually. The last 50 years has been one great spike in population growth rates, unprecedented in our history and destined to end soon.[14] No other primate, perhaps no other mammal, has ever done anything like this in the history of life on Earth. Consider this: roughly 10-15 percent of the years lived by people and their hominid ancestors going back four million years have been lived after 1957.[15] A memorable way to visualize it comes from the Italian historian Carlo Cipolla: if post-1957 population growth rates had obtained from the dawn of agriculture 10,000 years ago to the present, Earth would now be encased in a ball of squiggling human flesh expanding outwards into space with a radial velocity greater than the speed of light, gobbling up planets and stars in its path.[16] (Just as well that didn't happen I suppose, even if it might have saved us the trouble of space exploration.) What did happen was remarkable enough.

Connected to this stunning growth of population is the sudden urbanization of our species. For our first few hundred thousand years on Earth, our characteristic habitat was savanna grasslands and parklands, riverbanks, and shorelines. For a brief span, maybe 7000 or 5000 B.C. to A.D. 2000, the farming village formed the standard human habitat. But now, for the first time, the typical human animal has become a city dweller. In 1800, about 3 percent of the world's population lived in cities, and only one city, Beijing, topped one million. By 1957, about 30 percent of us lived in cities, close to a billion people in all. And today, more than half of us, over three billion souls, are urbanites, and the world has some 468 cities with more than a million people.[17] In 1957, only one urban area, New York, housed upward of 10 million people. Now there are about 25 such megacities, the largest of which—Tokyo/Yokahama—

14. United Nations data appearing in Angus Maddison, *The World Economy: Historical Statistics* (Paris: OECD, 2003), pp. 255-256.

15. This figure is adapted from calculations made by J. N. Biraben, "Essai sur l'évolution de nombre des homes," *Population*, 34 (1979): 13-24; and J. Bourgeois-Pichat in, "Du XXe au XXIe siècle: Europe et sa population après l'an 2000," *Population* 43 (1988): 9-42.

16. Carlo Cipolla, *An Economic History of World Population* (Harmondsworth, UK: Penguin, 1978), p. 89.

17. According to Thomas Brinkmann's Web site at *http://www.citypopulation.de/World.html* (accessed September 4, 2007).

is home to some 33 million people, roughly the population of the entire United States at the time of the Civil War. Cities everywhere used to serve as a check on population growth because their infectious diseases killed people faster than others were born. But in the last few decades this has changed and cities are no longer demographic black holes, but instead hothouses of further growth.

This is, to put it mildly, a bizarre transformation. It is less conspicuous in the United States, where half the population was urban by about 1920, than in Asia and Latin America, where things happened later and faster. In national terms, the fastest large-scale urbanizations in world history were those of the Soviet Union in the 1930s (while building socialism) and China since 1980 (while dismantling it). The urbanization of our species surely carries tremendous significance in ways not yet fully apparent. We have built new environments and new habitats while simultaneously populating them and leaving behind the milieux that formed us and our institutions.

One of the reasons that cities could grow as they did and do is the radical changes in energy use witnessed in our times. Before the era of fossil fuels, cities in temperate latitudes, say North China or Europe, needed to command an area of forest some 50 to 200 times their own spatial size to meet their fuel wood needs.[18] This, together with limits to agricultural efficiency, constrained urban growth. Fossil fuels broke this constraint, and helped break the ones on agricultural efficiency. Since 1957, global energy use has almost tripled, largely as a result of the globalization of oil use. Oil was a small part of the energy mix outside of North America until the 1950s. What China and India are doing now in terms of deepening energy and oil appetites, was done by Western Europe and Japan on a smaller scale from the mid-1950s to the 1970s.[19]

Again, as with urbanization, the significance of fossil fuels since the 1950s is less conspicuous in the American context than elsewhere because they became important in the United States earlier. But in global terms, it is only after the 1950s, with the opening of the so-called elephant fields in Saudi Arabia, and then those in Western Siberia, that cheap energy became routine. With cheap oil, automobiles became the normal accoutrements of middle-class and, in richer countries, working-class life. Furthermore, transportation of goods around the world became far more practical, leading to ever more complex divisions of labor and levels of specialization that enabled larger and larger numbers of people to live lives of ease instead of near-universal grim and grinding toil.[20]

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18. Vaclav Smil, *Energies*, (Cambridge MA: MIT Press, 1999), p. 118.

19. Useful histories of energy include Vaclav Smil, *Energy in World History* (Boulder, CO: Westview Press, 1994); Alfred Crosby, *Children of the Sun: A History of Humankind's Unappeasable Appetite for Energy* (New York, NY: Cambridge University Press, 2006).

20. This is explained for Europe in Christian Pfister, *Das 1950er Syndrom: Das Weg in die Konsumgesellschaft* (Bern, Switzerland: Paul Haupt Verlag, 1995).

Cheap energy is probably the single most important factor behind the spectacular economic growth of the last half century. For most of human history, the global economy grew at a snail's pace and, indeed, often shrank. The period since the middle 1950s, however, has chalked up by far the fastest growth rates ever posted. In the last five decades, the global economy has grown by about four percent per annum, twice as fast as during the second quickest era of expansion, which was 1870-1913. In per capita terms, the global economy has nearly tripled since 1957.[21] Of course, this is a very uneven achievement as some populations—in Central Africa for example—have scarcely benefited from this trend, while others, such as those in East Asia or southern Europe, have experienced far higher than average per capita income growth. For its overall growth, and for its wild geographic unevenness, the economic history of the last half century is far and away the most eccentric in the human record. This would be obvious to all if we did not naturally assume that what we have known from our own experience and observation is normal.

The extraordinary histories of population, urbanization, energy use, and economic growth over the past half century have combined to produce the most turbulent times yet in the history of human relations with the biosphere. Since at least the harnessing of fire, humans have had an outsized impact on Earth. That impact grew more widespread and profound in the 19th century when population growth and energy use began to climb at hitherto unprecedented rates. But the impact entered a new, tumultuous phase in the 1950s, so distinctive that the Nobel laureate chemist Paul Crutzen labeled it the "Anthropocene,"[22] the geological epoch dominated by human influence.

Since the dawn of the Space Age, the carbon dioxide concentration in the atmosphere has risen by a fifth, and global climate has begun to warm. Global forest area has declined by about 11 percent and grasslands by 19 percent. Freshwater use has tripled, and global irrigated area is up by 240 percent. Sulfur dioxide emissions have at least doubled (and that counts their decline in the United States and Europe since 1980). Same with methane emissions. Livestock numbers—mixing sheep, goats, pigs, and cattle together, no doubt an Old Testament, as well as methodological, abomination—are up about 170 percent. Cement production is up eight-fold.[23] You get the picture. Despite some improved technologies and

21. Maddison, *The World Economy*, pp. 260-262. See also Eric Lambin, *The Middle Path: Avoiding Environmental Catastrophe* (Chicago, IL: University of Chicago Press, 2007), pp. 26-28.

22. See Will Steffen, Paul Crutzen, and John R. McNeill, "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?" *Ambio* 36, no. 8 (2007): 614-621.

23. Data from the database maintained by Kees Klein Goldewijk at *www.mnp.nl/hyde/bdf* (consulted on September 4, 2007).

greater efficiencies in resource use, the economic miracle of the last half century has put unprecedented pressures on the biosphere that sustains all life.[24]

In the fullness of time, this environmental turbulence may come to appear the most important thing in the history of our times, more so than the Cold War; decolonization and the end of the British, French, Soviet and other empires; the growing emancipation of women; the rise of terrorism; the rise of China; the resurgence of political religion; the splitting of the atom; the decipherment of the human genome; or globalization. That remains to be seen: what is important about a given era depends entirely on what happens next. Should the stresses and strains upon the biosphere turn out one day to have been a mere tempest in a teacup, then this suggestion will have proved wrong. But if they build over time and prove disruptive in human affairs, then they will seem more meaningful, in time, than what preoccupied those alive in the second half of the 20th century.

THE PLACE OF SPACE EXPLORATION IN THE SPACE AGE

Given all these developments of the last 50 years that I claim are unprecedented, remarkable, revolutionary, and so forth, where do space exploration and space programs fit in? I am tempted to take refuge in the wisdom of Zhou Enlai (1898-1976), Mao Zedong's urbane foreign minister. French journalists in the 1960s asked Zhou what he thought was the significance of the French Revolution of 1789. Zhou paused thoughtfully and said that "it is too soon to tell."[25]

It is in fact too soon to tell what the real significance of the Space Age may be. At the moment, space exploration, space flight, and space research, all seem, at most, secondary next to the dominant trends of contemporary history. Moreover, nothing to do with space seems central in the sense that, had there been no Space Age, no Gagarin or Glenn, no Moonshot, no Hubble Telescope, no Laika, everything else probably would have unfolded much the way that it did. Some things would have been a bit different without spy satellites, communications satellites, weather satellites, Earth-observation satellites, and so forth. Hurricane Katrina (2005) and other weather disasters could have been even worse had we not known in advance what was coming. Figuring out the ozone hole over Antarctica would have taken longer.[26] But I am skeptical of the

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24. An excellent study that shows the interplay of economic expansion and increased efficiencies in the Spanish national economy is Oscar Carpintero, *El metabolismo de la economia española: Recursos naturales y huella ecológica (1955-2000)* (Madrid: Fundación César Manrique, 2005).

25. This phrase is variously reported, for example, as "too early to tell" in Wikiquote (*en.wikiquote.org/wiki/Zhou_Enlai*). In any case, Zhou spoke with French journalists in French as he had studied in France for three years in his youth.

26. See Ray A. Williamson and Henry R. Hertzfeld, "The Social and Economic Impact of Earth Observing Satellites." In: Steven J. Dick and Roger D. Launius, eds., *Societal Impact of Spaceflight* (Washington DC: NASA, 2007), pp. 237-266.

view that, for example, spy satellites prevented the Cold War from turning into World War III. The big things would *probably* be much the same, for better or for worse. I write "probably" in italics as a way to convey uncertainty because I am conscious that there are many things about space programs that I do not know. Furthermore, questions of causation in counterfactual scenarios are inherently unknowable, even for the best informed.[27] Had hundreds of billions of dollars and trillions of roubles not been spent on space, what might they have been used for? We can't know, but my guess is nothing out of the ordinary, that is, a little more of both guns and butter.

Perhaps space programs indirectly affected the big trends, even if spy satellites cannot be credited with preventing World War III. Could, for example, the current surge of globalization have derived some of its momentum from an enhanced awareness that we are all in the same boat, all stuck on the same small blue dot spinning through the darkness? Or could it owe something to instantaneous communications via satellites?[28] My view is the best answer is: yes, but not much. If no one had ever seen photos of Earth from space, and if information from India and Indonesia still arrived by telegraph and took a day or two to reach other continents instead of a second or two, would globalization be substantially different?

Space programs, of course, had spinoffs that affected contemporary history. The two most consequential so far are communications satellites and (very indirectly) the Internet. Nearly two-thirds of all satellites are used for communications,[29] and they have dramatically lowered the time and cost required for long-distance communications. The Internet arose from the Defense Advanced Research Projects Agency (more familiarly known as DARPA), which itself was created in response to the successful launch of Sputnik. These are both developments of consequence in today's world. But the Internet would likely have evolved, in somewhat different ways no doubt, even without DARPA. And in the absence of communication satellites, what they now transmit would likely go via the Internet (as, increasingly, long-distance phone calls do now). These musings reinforce the conclusion that space programs changed the history of our times, but not (yet) in any fundamental ways. Contemporary history, however, will inevitably look different to those no longer in the middle of it.

Space exploration, as opposed to the totality of space programs, could well be relegated to the status of historical footnote if, in the years ahead, exploratory probes are shut down. Satellites in near orbit are surely here to stay for a while,

27. For a more favorable assessment of the significance of space programs, see Erik M. Conway, "Overview: Satellites and Security: Space in Service to Humanity." *Societal Impact of Spaceflight*, pp. 267–288.

28. James A. Vedda, "The Role of Space Development in Globalization." *Societal Impact of Space Flight*, pp. 193–206.

29. *The Washington Post,* October 2, 2007: A1, A6.

as they serve several useful purposes, and some of them at least are profitable. But exploration programs are another matter: they are especially expensive and, since they probably won't cure cancer or defeat terrorism, they are at high risk of being phased out by Congress and its equivalents in other lands when money gets tight. If so, in time space exploration will be forgotten, a dead end, a historical cul-de-sac. On the other hand, it could be that space exploration will thrive, find new budgetary champions in the corridors of power, perhaps in China if not elsewhere. The likely endurance of geopolitical rivalry means space exploration programs will probably have some appeal, partly practical, and partly for propaganda value. It could well be, given the appreciation of the risks involved, that robotic space exploration will have a long future but human space flight will not. This, I imagine, is more likely to be the case if the sponsors are aiming at practical benefits rather than rewards in terms of prestige and propaganda, for which heroic humans still, and perhaps always will, carry outsized value.

One way to look at the experience of space exploration, and one justification for its endless continuation, is to see it as a species of expeditionary science. Past rulers have often sent out scouts, spies, and scientists to take inventory of the resources and peculiarities of other lands. In the 18th century, Britain and France competed for geopolitical dominance in several parts of the world, and in that context sponsored scientists and scientific expeditions to gather useful information, whether about medicinal plants, trees suitable for naval timber, or a thousand other things that might come in useful one day. When Napoleon conquered Egypt in 1798, he loosed a team of scholars and scientists upon the country to ransack it for information (and art) of all sorts. From Russia to Spain, all European states with overseas interests sponsored expeditionary science on some scale, as in time did the United States. When Jefferson purchased half a continent from Napoleon in 1803, he bankrolled Lewis and Clark to take a preliminary inventory of what he had bought. During the Cold War, the United States and the U.S.S.R. sponsored scientific expeditions on a much more lavish scale to the polar regions and deep beneath the seas. Their space programs were, among other things, part of this tradition.

Space exploration may survive on one or another basis, but it still will not loom large in terms of human history unless something really new and interesting happens, the sort of thing people in the space business probably dream about—finding intelligent and agreeable (or at least neutral) life out there or colonizing new corners of the universe—or probably have nightmares about—developing effective space-based weapons suitable for use against earthly enemies or finding intelligent but hostile life out there. If any of these things happen, then the first 50 years of space exploration will look like the beginning of something of epic significance. If they don't, it will look like a small step for mankind that led nowhere, and did not amount to much in the balance before being consigned to the dustbin of history. It is indeed too soon to judge whether the whole enterprise is a gigantic folly diverting money and talent from more urgent applications, a noble calling consonant with our deepest nature, or something else altogether.