

**SPACE AND THE
AMERICAN
IMAGINATION**

To my classmates at Queen Anne High School
Seattle, Washington
Class of 1959

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The Extraterrestrial Frontier

Space: the final frontier ...

— Captain James Kirk

At Epcot, the large theme park that opened near Orlando, Florida, in 1982, the Walt Disney Company constructed a colonial-style building called the American Adventure. Nearby exhibits honored, among other cultural traditions, Japanese art, Moroccan architecture, French cooking, and German beer. The American pavilion celebrated U.S. history. In the central rotunda, designers placed a mural depicting the evolution of NASA's space shuttle. Next to it they set a quotation from historian and philosopher Ayn Rand praising the generations of Americans "who took first steps down new roads armed with nothing but their own vision."¹

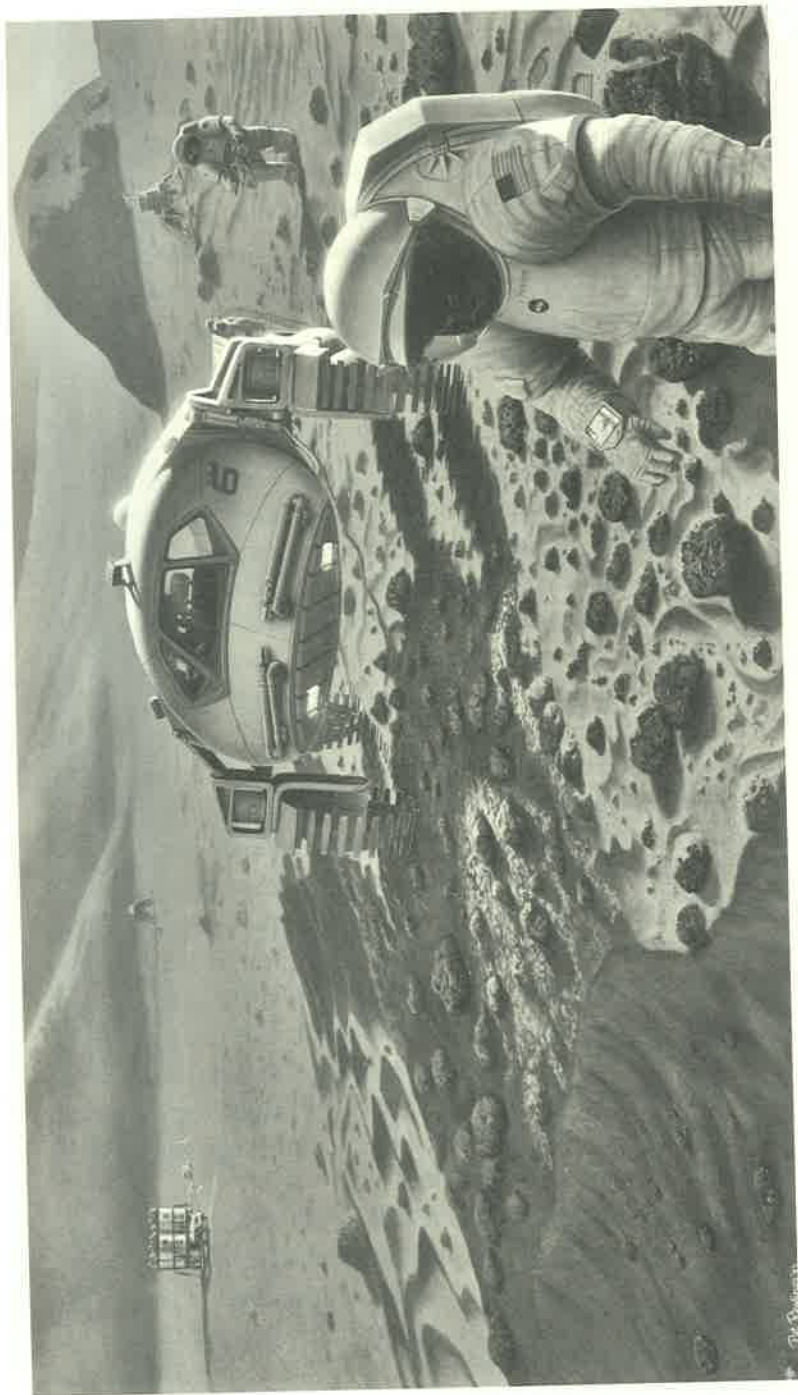
For many partisans of space flight, the U.S. cosmic adventure promised to maintain America's special characteristic. Space travel promised far more to them than the opportunity to unlock the mysteries of the universe. The undertaking provided an opportunity to continue the practices that had spurred invention and innovation and made America great. Those prac-

tices arose from the willingness of Americans to take the "first steps down new roads," from the great migrations that brought people to the continent to the settlements and industries they founded. If space exploration is just about science, then the vision of space travel with its persistent emphasis on human flight is headed down the wrong path. To its most devoted advocates, space exploration promises more. To them, human space travel has value in its own right. It presents an opportunity for Americans to move their culture of invention and innovation outward, beyond the Earth, in ways that will make it last forever. Among the core of true believers, devotion to this point of view is extremely strong.

This vision manifests itself in the idea of space as a final frontier. For nearly all of its history, American has been a frontier nation. Waves of people have spread across the continent and learned how to live on unfamiliar lands. After 1900, when the availability of open land diminished, Americans continued the frontier tradition through expeditions to the poles, further immigration, the development of technology, and the exploration of space. Within the culture at large, the frontier experience is thought to have shaped American culture in distinct ways, encouraging ingenuity, invention, innovation, equality, democracy, and material progress. Without a continuing frontier, from this point of view, these characteristics will disappear. Americans will cease to be unique. They will become like people in more static countries and their special culture will cease to be a force advancing the future of humankind.

The vision of humans in large numbers moving out across an extraterrestrial version of a frontier trail is an ambitious one. Most Americans experienced the space program vicariously, as armchair explorers viewing television reports or images on book pages or computer screens. In the first half century of flight, only a few hundred people actually ventured into space. As the space program matures, its advocates claim, this will change. Americans in large numbers will join the venture, reactivating the vast migrations that shaped the country in the past. Humans will move into space in multitudinous throngs, repeating the process of exploration, invention, and settlement.

The vision of space as the final frontier is controversial. Realization dampened promise as humans failed to move into space in the anticipated numbers. Visionaries anticipated that space stations would house scores of people; the International Space Station holds less than a dozen. Advocates of the frontier analogy visualized lunar bases with hundreds of people and space colonies attracting millions. At least through the early phases, space has turned out to



Space advocates promised that extraterrestrial exploration would renew the frontier spirit they said had made America great. Just as nineteenth-century artists like Albert Bierstadt portrayed pioneers crossing western trails, space artists prepared pictures of Americans traversing the space frontier. In this 1993 painting by Pat Rawlings, explorers in spacesuits and a pressurized rover advance through the Ganges Chasma canyon on Mars. (NASA)

be more like the seabed than the frontier—a nice place to visit but not a great place to live.

The frontier analogy contains a strong element of utopianism, attractive to people who believe in it but curious to those who do not. Utopian societies rarely turn out to be as special as their visionaries proclaim. Professional historians question the role of frontiers in fostering the special characteristics so frequently ascribed to them. To historians, the idea of the frontier contains more myth than substance. The American public may embrace the virtues of frontiers, but to historians the popular image is a post-frontier phenomenon, perpetuated by vehicles like the Hollywood western.² Promoters of space as the final frontier offered their special vision just as revisionist historians mounted a full-scale campaign to debunk the notion, undercutting the analogy, at least within intellectual circles, where ideas about public policy mature. Promoters not only had to overcome skepticism about the technical feasibility of space colonization but also had to deal with suspicions about the historical accuracy of their ideas.

Still, frontier analogies continued to play an important role in the promotion of space exploration. One of the most popular analogies draws on the public's memory of sea captains, who in centuries past crossed vast bodies of water to reach distant lands. The only event comparable to the first landing on the Moon, editorial writers at both the *Washington Post* and *Washington Daily News* agreed, was "Columbus' discovery of the Western Hemisphere."³ To commemorate the five hundredth anniversary of the first voyage of Christopher Columbus to the New World, a NASA-sponsored organization prepared a comic book for young children explaining the similarities between the challenges Columbus faced and those encountered by modern spacefarers. "Just as Christopher dreamed about opening a new trade route to the Far East, we can dream about a clean and beautiful Earth, about other space routes to Mars and colonization of our neighbor, the Moon."⁴ Members of the 1986 National Commission on Space chose as the title for their report *Pioneering the Space Frontier*. Charged by the president and Congress to set out civilian space goals for the twenty-first century, members opened with the Columbus analogy: "Five centuries after Columbus opened access to 'The New World' we can initiate the settlement of worlds beyond our planet of birth. The promise of virgin lands and the opportunity to live in freedom brought our ancestors to the shores of North America. Now space technology has freed humankind to move outward from Earth as a species destined to expand to other worlds."⁵

In explaining his plans for gravity-assisted spacecraft that could cross the expanses of space between Earth and Mars, Buzz Aldrin drew on lessons from fifteenth-century maritime explorers. After his astronaut career, Aldrin worked hard to promote interplanetary exploration. Aldrin reminded Americans that European mariners of the fifteenth century had used the tropic winds that blow westward across the equator to reach the New World: "The new routes did not follow direct courses but instead looped along curving paths that sometimes appeared to carry the mariners away from their objective." The trade winds provided a pathway between the two continents, "making possible the great age of discovery."

Having established this analogy, Aldrin proposed that reusable spacecraft, called cyclers, be set into permanent orbits between Earth and Mars. The cyclers would use the force of gravity to whip by each planet, accelerating to the required velocity for the ensuing voyage. Smaller spacecraft would intercept the cyclers to move people and supplies home. Earlier routes of discovery provided the analogy that Aldrin needed to explain his plan: gravity provided a free and inexhaustible source of motion for interplanetary travel, just as trade winds had done for maritime explorers. "Like a ship sailing the trade winds," cyclers would follow a broad elliptical path rather than a more direct route between the two planets.⁶

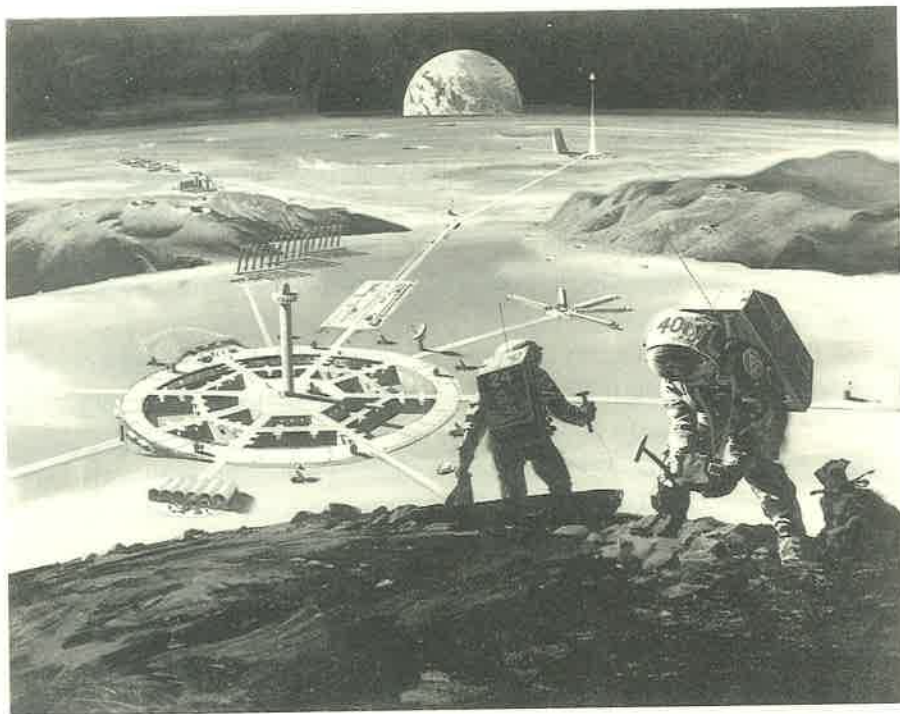
Memories of the debate between Queen Isabella and her advisers over the Columbus voyage repeatedly appear in the consideration of modern space policy. "The many uses of space technology will make our investment in space as big a bargain as that voyage of Columbus," said governor of California Ronald Reagan. At the time, Reagan reminded his audience, support for the Columbus expeditions "was denounced as a foolish extravagance."⁷ It is true that the Talavera commission set up by King Ferdinand and Queen Isabella of Spain had in 1490 issued a recommendation against financing the voyage. Although the monarchs did not follow the advice of the commission, the legend that the queen borrowed money for the expedition by pledging her crown jewels as collateral is untrue. That piece of folklore nevertheless played a prominent role in modern space policy debates. When space advocates first presented plans for a lunar voyage to President Dwight Eisenhower, they employed the Columbus analogy to justify the undertaking. Eisenhower reportedly countered that he was "not about to hock his jewels" to support a lunar expedition. Regardless of whether Eisenhower actually said any such thing, the story became an emblem of his modest space effort.⁸ Queen Isabella came up again at a meeting of

the Cabinet Council on Commerce and Trade in December 1983 as President Reagan and his advisers considered the proposal to start work on an Earth-orbiting space station. Budget director David Stockman, an opponent of the station, announced that the administration would never control the deficit if it continued to support such questionable projects. Attorney General William French Smith countered that Queen Isabella must have heard the same story from her advisers. The simple reference to the Columbus myth was enough to disarm Stockman's objection and make everyone, including the president, laugh.⁹

In their attempts to justify modern space endeavors, advocates have consistently appropriated the image of new frontiers. Americans have a "continuing urge to chart new paths and to explore the unknown," NASA administrator James Beggs said in announcing NASA's effort to win political support for a large space station. "That instinct drove Lewis and Clark to press across the uncharted continent. It guided admirals Peary and Byrd to the icy wastes of the poles. It drove Lindbergh alone nonstop across the Atlantic and sustained twelve Americans as they walked on the moon." The compulsion to probe unknown frontiers spurred the creativity of Americans. "If we ever lose this urge to know the unknown," Beggs argued, "we would no longer be a great nation."¹⁰

During the early part of the twentieth century, explorers like Robert Byrd, Roald Amundsen, and Robert Scott probed the icy regions of the South and North Poles. To many, it represented the last great era of discovery on the surface of the Earth. "The lonely explorers like Ronald [*sic*] Amundsen, Robert Scott and others who endured the rigors of Antarctica in the early decades of this century are analogous to our space pioneers today," Beggs argued in a 1984 speech. Scott had died in his effort to beat Amundsen to the South Pole, an event that transfixed the attention of armchair explorers around the world. "This is as close as you and I are going to get to setting foot on another planet," explained a member of the U.S. team conducting research on the Antarctic ice.¹¹

Analogies extend from sea captains and explorers to the settlement of the American West. Speaking at the July 1982 landing of the space shuttle *Columbia*, President Ronald Reagan announced that the conclusion of the flight test program was "the historical equivalent to the driving of the golden spike which completed the first transcontinental railroad." During the easy-money years following the decision to go to the Moon, NASA actually funded a project



According to space advocates, frontiers foster innovation and discovery. When the urge to explore is curtailed, advocates warn, civilization decays. A key step in the opening of the space frontier would be the establishment of bases on the Moon, described in works of imagination both fantastic and real. (Lockheed Martin Missiles and Space Photo Archive)

that paid social scientists to determine whether the railroad analogy could be used to explain the U.S. space effort.¹² Defending his proposal to send a human expedition to Mars, President George H. W. Bush announced that “throughout our history, America has been a nation of discoverers.” It would be hard to imagine Thomas Jefferson “sending a robot out alone to describe the wonders of the American Rockies and the Pacific coast.”¹³ Robert Zubrin, one of the most vocal advocates for the settlement of Mars, argued that only a planetary colony would provide the stimulus necessary to maintain a technologically advanced civilization. “Apply what palliatives you will, without a frontier to grow in, not only American society, but the entire global civilization based upon values of humanism, science, and progress will ultimately die.”¹⁴

Where do these ideas come from? In large measure, they arise from Turner-

ism, the most influential doctrine affecting the teaching of U.S. history during the first half of the twentieth century.¹⁵ Widely disseminated to the generation of Americans who managed the early space program, Turnerism remained popular with the educated public even as academic historians tried to debunk the doctrine. Frederick Jackson Turner was a young history professor at the University of Wisconsin when he delivered his 1893 paper on “The Significance of the Frontier in American History.” He traced many of the distinctive characteristics of American society to the influence of free land across an open frontier. Inquisitiveness, inventiveness, and individualism were American traits forged on the frontier, Turner argued. Once created, these traits persisted even after the actual conditions of frontier life had disappeared. Turner traced the rise of American democracy and extended suffrage to social conditions on the frontier. Frontier life, according to Turner, bred a love of liberty that found its expression in the political doctrine of self-rule, and migration of many people to the frontier provided a powerful engine for the cross-fertilization of ideas and cultures that promoted America’s sense of national identity. Turner’s thesis inspired an outpouring of books on what became known as the idea of American exceptionalism.¹⁶

As Turner’s paper observed, the American frontier closed in 1890. Quoting a brief official statement from the superintendent of the census, Turner noted that the distinctive, ever-moving line of settlement that had characterized America since its founding ceased to exist as of that year. Gone with it was the source of “this perennial rebirth, this fluidity of American life, this expansion westward with its new opportunities.”¹⁷ Other historians attacked Turner’s thesis, insisting that American ingenuity and democracy could be traced to experiences other than the frontier.¹⁸ But to advocates of space exploration, the Turner doctrine, however dimly understood, became the basis for a new adventure.

The more academic historians sought to discredit the myth of the frontier, the more space advocates exploited it.¹⁹ Advocates of space exploration offered the extraterrestrial frontier as a place to energize the human spirit. All of the talk about technology spinoffs and scientific instruments faded in comparison to this aim. To the proponents of space exploration, modern civilizations need frontiers in order to maintain human innovation. Anticipating the colonization of Mars, the editors of *Life* magazine predicted that “a frontier ethic that celebrates courage, independence, imagination and vitality will merge with a technological bias that from necessity mothers inventions.”²⁰

In the minds of human space flight advocates, new challenges revitalize cultures grown stale. The exploration and eventual settlement of space offers such a challenge, and its advocates take comfort in the thought that similar animations of human spirit followed previous epochs of discovery. Even an outlet as skeptical as the *Washington Post* embraced this point of view. Commenting on John Glenn's first orbital flight in 1962, editorial writers at the *Post* likened the venture to the inspiration occasioned by an earlier age of discovery: "There is something in the very air of this space age that is not unlike the climate of another great age of discovery which took place in the fifteenth century." Europe at the end of the 1400s was gripped in a period of depression and anxiety, the *Post* writers observed. Quoting from the historian Samuel Eliot Morrison, editorial writers announced that fifteenth-century Europeans felt "exceedingly gloomy about the future." Their influence was shrinking, efforts to recover the Holy Sepulcher at Jerusalem had failed, Christianity was losing ground to Islam, and the Ottoman Turks had overrun most of Greece, Albania, and Serbia. "Then came an event that to Fifteenth Century Europe must have been quite as astonishing and breath-taking as the voyage of the Friendship VII. Into Lisbon harbor, came the Nina, sailing before a wintry gale to bring news of the discovery of the new world. That news changed the spirit of Europe. In Morrison's words: 'New ideas flared up throughout Italy, France, Germany and the northern nations; faith in God revives and the human spirit is renewed.'" Revolutions in science, philosophy, and religion followed, which the *Post's* editorial writers optimistically ascribed to those early voyages of discovery. "So must these ventures into our space environment revive and renew the human spirit," the *Post* promised. The message so impressed the *Post's* editorial writers that they repeated it when the Apollo 11 astronauts landed on the Moon.²¹

Maintaining a spirit of discovery is not easy. Learning science and technology is hard. Periodically, societies turn away from science and construct alternative cultures. "History offers many trenchant examples of what happens when the urge to explore and the development of new technology are forcibly curtailed," said NASA administrator James Beggs, commenting on the American withdrawal. Delivering a lecture before the Royal Aeronautical Society in 1984, Beggs once again reminded his audience of the experience of the fifteenth century, this time turning attention not to the accomplishments of Christopher Columbus but to the experience of the Chinese. Seventy-five years before the Columbus trip, Ming emperor Yung-lo authorized a series of voyages to contact Western people and participate in their affairs. Before the ships

could reach Europe, conservative Chinese leaders prohibited private contacts with foreigners and forbid the launching of private voyages. Europeans moved out; Chinese turned in. By the technological and economic standards that came to dominate the world, the decision stunted Chinese civilization for centuries to come. By abandoning our exploration program, another NASA administrator added later, "we risk making the same mistake the Chinese emperors made more than 700 years ago."²²

This admittedly ethnocentric view of the world gives little credit to the accomplishments of alternative cultures. In the minds of space advocates, however, it is how the world works. Frontiers imply conquest. History favors ethnocentrism. "The process of pushing back frontiers on earth begins with exploration and discovery, which are followed by permanent settlement and economic development," Beggs bluntly observed. Confrontations between technologically advanced civilizations and inward-looking ones inevitably work to the detriment of the latter. When societies collide, the exploring culture invariably wins. That is why the histories of inward-looking peoples are so frequently written in the language of their conquerors.²³

Advocates of space exploration embrace a frontier philosophy that to some seems sternly paternalistic. Dominate or perish, they say. For many, it is a matter of national survival. When John F. Kennedy accelerated the space race with his decision to go to the Moon, he did so because he wanted to preserve the American way of life. "Only if the United States occupies a position of pre-eminence can we help decide whether this new ocean will be a sea of peace or a new terrifying theater of war," Kennedy argued in defending his space policy at Rice University in 1962. "No nation which expects to be the leader of other nations can expect to stay behind in this race for space."²⁴ The exploration of space would go ahead, he assured his audience, whether or not the United States led it.

For others, moving into this new frontier is a necessity for survival. A species cannot remain on a single planet for any extended period of time, Carl Sagan observed. On a single planet, it will certainly perish—its demise assured by astronomical events such as asteroid strikes or homegrown catastrophes: "Every surviving civilization is obliged to become spacefaring—not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive." NASA administrator James Fletcher offered a similar argument in 1975. Any people who turn their back on the future will lose control of their destiny, he said. "Like Darwin, we have set sail upon an ocean: the cosmic sea

of the Universe. There can be no turning back. To do so could well prove to be a guarantee of extinction." The great rocket pioneers Robert Goddard and Konstantin Tsiolkovsky both agreed that the navigation of interplanetary space was essential for the continuation of the human race.²⁵

To all of its advocates, space frontiers promise to keep the spirit of innovation alive. "Frontiers summon the creativity, imagination, and inventiveness of the human mind," said Walter Hickel, governor of Alaska and a frequent space booster. "Civilization needs big projects, the kind that ignite the mind and inspire the soul." Imagination inspires new ideas in science and technology, James Beggs maintained. It nourishes art and literature and promotes the notions of freedom and self-fulfillment that people in democratic societies hold dear. "Small wonder," Beggs said, "that those nay-sayers and disbelievers who have ignored imagination and its potential to shape our destiny leave only a few, faint footprints on the sands of history."²⁶

Promoters of space frontiers place a great deal of faith in the inspirational effects of exploration. "Looking back to the early navigators," NASA administrator Thomas Paine said in 1969, "the thing that impresses you is not the culture that they carried to continents like North and South America, Africa, Australia, and the Far East, but the effect of the culture that they brought back to Europe."²⁷ They brought back a global perspective that transformed the exploring nations and dominated civilization for the next five hundred years. They did not simply prove that the world was round (in any case, few educated people in Columbus's time subscribed to the flat Earth doctrine). Rather, explorers brought back a view of the world that encouraged the development of new technologies, such as sailing ships and navies that could master the seas. This New World view encouraged global commerce and global migration. It inspired scientific discoveries that would have been impaired in more repressive, inward-looking societies. In the geography of the seafaring world, Europe sat at the center of the map.

In another burst of Turnerism, Paine insisted that frontiers were responsible for the rise of democratic governments around the world. As Europeans settled new continents such as North America, they experimented with new forms of government needed to "conquer and organize a new continent." Historians agree that the absence of European institutions provided a fertile environment for the development of liberal democracies such as those that arose in Canada and the United States. Paine suggested that democratic ideas inevitably filtered

back to Europe. The development of democratic governments in North America, he said, "set a new standard for governments around the world" and inspired the adoption of democratic reforms elsewhere.²⁸ The notion that frontier conquest promotes democratic government is not a new idea, but neither is it without controversy. Many factors encouraged the development of democracy in Europe, of which the experience in far-away America was only one.

"As we sail the new ocean of space," Paine insisted, "we are carrying out the same kind of exploration that the early navigators did when they set forth from Western Europe in their first ocean-going vessels." Fresh social transformations would surely follow as humans ventured away from the Earth.²⁹ Advocates of space exploration have had little difficulty imagining that these things will occur. However fuzzy or inaccurate their knowledge of history, they have not hesitated to apply it to the space frontier.

As Americans prepared to land on the Moon, enthusiasts made plans to settle space. NASA officials commissioned a number of studies in preparation for the establishment of bases on the Moon.³⁰ Engineers hoped to develop a twenty-five-thousand-pound module that could be launched using the Saturn V rocket and land softly on the Moon.³¹ One proposal contemplated the establishment of four lunar bases, two at Grimaldi Crater, one on the far side of the Moon, and a fourth at the lunar south pole.³² One of the more imaginative proposals appeared in the 1968 movie *2001: A Space Odyssey*, in which screenwriter Arthur Clarke describes Clavius Base, located in the second largest crater on the visible side of the Moon. In an emergency, the colony could be entirely self-supporting. Clarke anticipated that elements such as hydrogen, oxygen, and nitrogen could be produced from local rocks crushed, heated, and chemically treated on the Moon. Food was produced in an underground biosphere that also served to purify air. A variety of transportation vehicles, most moving on flex wheels or balloon tires, carried crews to various parts of the lunar surface. Eighteen hundred men and women lived and worked at the fictional base, which, in the optimism of the day, had been established by the U.S. Corps of Astronautical Engineers in 1994.³³

The anticipation of large numbers of people on extraterrestrial bodies like the Moon excited a complementary strain of thought, one closely associated with the doctrine of frontiers. To inspire fresh ideas, Robert Zubrin argued, a frontier needs to be sufficiently remote "to allow for the free development of a new society." For Zubrin, that could "only be on Mars." Zubrin bypassed

interest in lunar bases in favor of Martian colonies. The Moon was too close. "If people are to have the dignity that comes with making their own world, they must be free of the old."³⁴

In his famous collection of stories assembled within *The Martian Chronicles*, science fiction author Ray Bradbury describes colonists fleeing a disintegrating Earth and establishing a new society on Mars. The colonists call themselves Martians. "Earthian logic, common sense, good government, peace, and responsibility," says one of the colonists looking back toward an Earth destroyed by atomic war. "It's not there anymore."³⁵

The idea of starting over in a better place is as old as human hope. Sir Thomas More placed his fictional Utopia on an island in the New World. John Winthrop and his community of English Puritans came to Massachusetts. The Shakers, or members of the United Society of Believers in Christ's Second Appearing, settled in upstate New York, among other places. The Harmony Society, a German religious group, founded towns in Pennsylvania and Indiana. Persecuted in New York, Joseph Smith and Brigham Young led their followers toward a new city of Zion in Missouri, Illinois, and finally a western state they called Deseret. After the closing of the American frontier, British diplomat Hugh Conway set paradise in Shangri-La, a fictional community in the mountains of Tibet.³⁶

Traditional utopian communities in America were largely religious in origin. Believers sought out-of-the-way places in which to establish more perfect societies based on biblical teachings. As the country grew more urban and industrialized, utopian thinking shifted toward technology. Although religious and social utopias still persist, more modern forms anticipating perfection through expertise have joined them. Supporters of the technocracy movement, transhumanism, and the idea of a technological singularity foresee situations in which humans use science and technology to create more perfect worlds inside the old one. From their perspective, knowledge from science will abolish poverty, suffering, and even death. In the early twentieth century, the technocracy movement sought to improve society by empowering scientists and other experts to make governmental decisions. The singularity is a predicted point in time, popularized by Ray Kurzweil, in which pace of technological change becomes so great that machines learn how to improve and think for themselves. Advocates of transhumanism envision a point in time at which humans live long enough to live forever.³⁷

The space pioneering movement achieves its distinctiveness by combining

the desire for new places with the idea that technology will make their settlement possible. As such, it contains the fervor of traditional religious utopias without the necessity of having to promote religious beliefs. Says Zubrin again: "Though the Red Planet may appear at first glance to be frozen desert, it harbors resources in abundance that can enable the creation of an advanced technological civilization. Mars is remote and can be settled. The fact that Mars can be settled and altered defines it as the New World." Zubrin embraces the classical utopian idea that righteous human beings cannot exist within a oppressive society; he offers technology as the means to create a new one. "Everywhere you look," he writes, "the writing is on the wall." Zubrin points to the concentration of wealth, the bureaucratization of life, the impotence of government, the spread of irrationality, the aversion to risk, economic stagnation and the loss of inventiveness. To a classical utopian, the solution is clear. Move on. Do so soon. "Can a free, egalitarian, innovating society survive in the absence of room to grow? Perhaps the question was premature in Turner's time, but not now. . . . Without a frontier from which to breathe new life, the spirit that gave rise to the progressive humanistic culture that America has represented for the past two centuries is fading."³⁸

Shortly after the landing on the Moon, a physics professor at Princeton University electrified the devoted corps of space frontier advocates with his proposal for moving out. In 1974 Professor Gerard O'Neill published what author Michael Michaud called "one of the most photocopied science articles in history."³⁹ O'Neill had challenged his students to consider whether a planetary surface like the Earth was the best place for an expanding technological civilization. Their answer, in typically utopian fashion, was no. O'Neill's solution was imaginative.

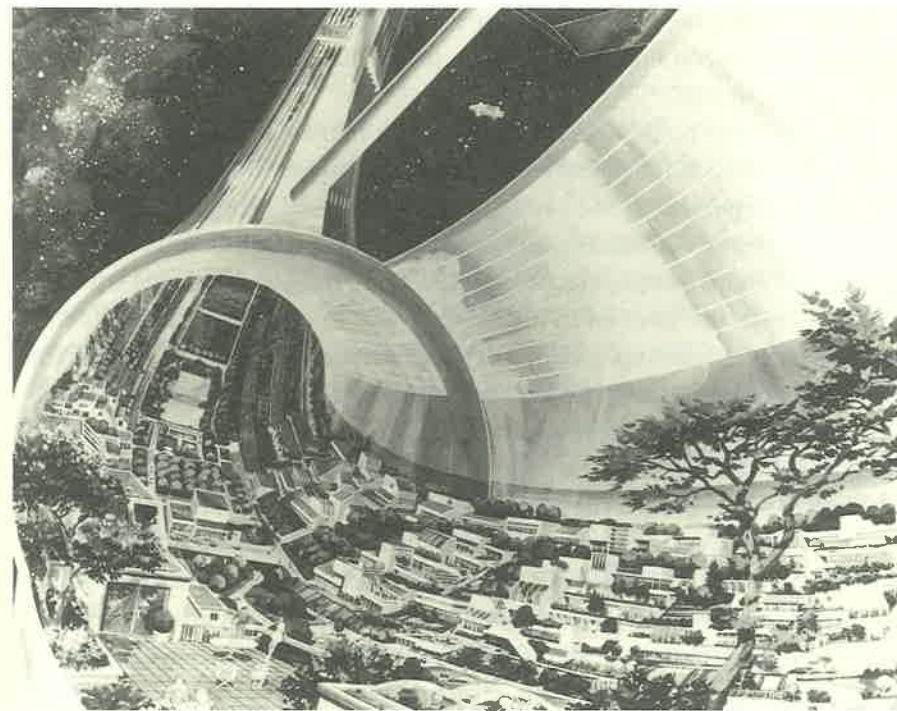
Writing in *Physics Today*, O'Neill described how humans could move off the Earth into a multitude of artificially constructed colonies located at gravitationally stable points in the emptiness of space. The most efficient design, he argued, would be cylinders about four miles in diameter and sixteen miles in length. People residing on the inner edge of the rotating cylinder would live in a technologically perfected Earth-like environment, with lakes, mountains, trees, suburbs, artificial gravity, and a blue sky spotted with clouds three thousand feet "above" the inner rim. Animals and plants endangered on Earth could thrive on these cosmic arks, but insect pests would be left behind, eliminating the need for pesticides. Light from the Sun would be directed into each cylinder from large movable aluminum-foil mirrors, which would create night and

day and seasons like those on the home planet. Ample electricity would be provided by steam-turbine generators, powered by the Sun and providing a clean source of energy for transportation and personal use. "With an abundance of food and clean electrical energy, controlled climates and temperate weather, living conditions in the colonies should be much more pleasant than in most places on Earth," O'Neill prophesied.⁴⁰

The first colony could be completed just after the turn of the century, O'Neill argued, in about twenty-eight years. With the manufacturing technology in place, the number of colonies could expand exponentially. A fully developed colony, he declared, could easily support a population of ten million people, plus desirable flora and fauna.⁴¹ Continuing those calculations, O'Neill estimated that emigration to the colonies could reverse the population rise on Earth by 2050. In another thirty years, Earth's population could be reduced "to whatever stable value is desired"—perhaps 1.2 billion people.⁴² Colonists would mine the Moon for materials to build the first colonies, then excavate the asteroids. After exhausting the asteroid belt, they could tear up the moons of the outer planets. The raw materials available in the solar system, O'Neill offered in a fit of enthusiasm, could support a twenty-thousand-fold increase in the human race while reducing population pressures on Earth.⁴³ It seemed too good to be true, and probably was.

A number of obstacles stood in the way. To construct the first space colony, the sponsoring nation would have to move some five hundred thousand metric tons of metal, soil, rock, and water to the construction point in space. And someone had to move the first colonists, a major challenge given the astronomical cost of transporting humans and their accompanying supplies from the Earth to extraterrestrial destinations.⁴⁴

O'Neill attacked these challenges with technological optimism. He urged colonists to acquire the bulk of the materials needed for the first space colonies from the Moon. To launch them toward the construction site, he proposed a type of recirculating conveyor belt called a mass-driver. Magnetic impulses produced by electric energy would accelerate a twenty-pound bucket of lunar material to the velocity necessary to hurl its contents toward the appropriate spot in space.⁴⁵ As for the problem of transporting people and a few essential materials from Earth, he accepted the widely held notion that reusable launch vehicles would reduce transportation costs by a factor of ten. O'Neill's supporters argued that the first space colony, a rather Spartan version, could be



Eventually humans would move into space in large numbers—some to the Moon and Mars and others to artificially constructed colonies suspended in gravitationally stable points of empty space. In 1974 physics professor Gerard O'Neill put forth a utopian proposal for a multitude of terrarium-like space colonies with living conditions superior to those found on a crowded Earth. (NASA)

constructed for about \$33 billion in 1972 dollars—roughly equivalent to the amount spent to send American astronauts to the Moon. Internal NASA studies set the price closer to \$200 billion.⁴⁶

O'Neill's space colony proposal was not unique, but the degree to which it captured the public imagination was. The idea of large artificial colonies in space had been advanced previously by an assortment of writers, from the famous to the obscure. At the beginning of the twentieth century, Russian space pioneer Konstantin Tsiolkovsky had envisioned dwellings in space that could house millions of people. British scientist J. D. Bernal advanced a similar concept in 1929, and Arthur C. Clarke helped popularize the idea in his 1954 children's novel *Islands in the Sky*. Dandridge M. Cole presented plans for space

colonies formed out of hollowed-out asteroids in 1964, and Krafft Ehrlicke, a member of the von Braun rocket team, issued his call for an "extraterrestrial imperative" in 1971.⁴⁷

Unlike earlier proposals, which attracted a narrow audience, O'Neill's vision splashed upon the public scene. It attracted interest from the mainstream of American politics to the cultural fringes of radical thought. His concept was embraced by visionaries who wanted to pioneer space, environmentalists concerned about overpopulation and dwindling resources, futurists who saw technology as the solution to human problems in an industrial civilization, and a variety of space-age groupies in occasional need of psychiatric help. The California-based counterculture group responsible for producing the environmentally correct *Whole Earth Catalog* promoted the idea. Congress held hearings, and NASA gave financial support to a variety of supporting studies.⁴⁸

Excited by the prospect of pioneering the high frontier, Americans throughout the 1970s in ever-increasing numbers filed into spacefaring clubs. O'Neill's vision spawned the L-5 Society, named after one of the gravitational stable regions created by the Earth and Moon at which objects such as a space colony could remain indefinitely. The main purpose of the L-5 Society, formed in 1975, was "to arouse public enthusiasm for space colonization."⁴⁹ The society attracted adherents whose exuberance about space colonization irritated people laboring on practical U.S. space activities. In response, industry and government leaders in 1975 formed the more conservative National Space Institute, at its head the aging space warrior Wernher von Braun, which sought to mobilize grass-roots support for NASA's more conventional exploration plans. In 1987 the two organizations forgot their differences and merged into the National Space Society. The society envisions "people living and working in thriving communities beyond the Earth, and the use of the vast resources of space for the dramatic betterment of humanity."⁵⁰

Strange and wondrous groups continued to form. Distracted at the cancellation of their *Star Trek* television series, science fiction fans organized local clubs and federations as a means of keeping their enthusiasm for galactic fantasies alive. Through a massive letter-writing campaign, "Trekies" convinced the government to name the first space shuttle test model after the starship *Enterprise*.⁵¹ Following the broadcast of the *Cosmos* television series, 120,000 individuals joined Carl Sagan and Bruce Murray in forming the Planetary Society. The society collected signatures of notable and ordinary Americans for its Mars Declaration, a statement advocating the exploration of Mars as an

important step "toward the long-term objective of establishing humanity as a multi-planet species."⁵²

By 1980, by one estimate, space enthusiasts had formed nearly forty major interest groups devoted to the cause of exploration and colonization. Local chapters, astronomical societies, and science fiction fan clubs pushed the total number of organizations close to five hundred.⁵³ They included groups promoting capitalism in space, groups advancing the role of women in space, groups set up to privately fund space activities, and groups prepared to train space pilots and pioneers. In 1988 Rick Tumlinson and some O'Neill acolytes established the Space Frontier Foundation. Taking its name from the impulse that drove adherents to dream of starting new places, foundation members dedicated themselves to "opening the space frontier to human settlement." Ten years later, Robert Zubrin formed the Mars Society "to further the goal of the exploration and settlement of the Red Planet." There was even a political action committee for space.⁵⁴

Many books and reports appeared advancing various scenarios for the accomplishment these goals. The most lavishly illustrated, if not widely read, was the 1986 report of the National Commission on Space, chaired by former NASA administrator Thomas Paine. Members of the commission recommended that the government establish an outpost on the Moon by 2006 and a human outpost on Mars by 2015. "Many of the people who will live and work at that Mars Base have already been born," the report's authors noted.⁵⁵

Members of the commission proposed an elaborate infrastructure in space. There would be an Earth-orbiting space station, a lunar-orbiting space station, and a station around Mars. A special spaceport at one of the gravitationally stable points near the Moon would prepare humans for the journey to Mars. There would be transfer vehicles designed to take humans between the stations. The commission proposed lunar landers and Mars landers and cycling spacecraft and special spaceships that could with a burst of speed catch the cyclers as they flew by.

Paine's report contained wondrous illustrations of the new frontier: men and women tending fruit trees and vegetables in a lunar biosphere, a spacecraft landing at a twenty-first-century Martian settlement, astronauts in space suits servicing a transfer vehicle at a gravitationally stable spaceport, and the same transfer vehicles using Earth's upper atmosphere for aerobraking maneuvers. In another illustration, a specially designed robot worked to mine propellants from Phobos, a moon of Mars. Preliminary studies indicated the presence

of water, carbon, and nitrogen on the tiny moon. "If so," commission members suggested, "there is an orbiting fuel depot just 6,000 miles above the red planet to top off the hydrogen and oxygen tanks of visiting spacecraft."⁵⁶ The commission hoped that the first occupants would obtain much of the material needed to set up their lunar and Martian outposts from local resources. Oxygen in the form of metal silicates might be extracted from the lunar soil, and Paine hoped that explorers would locate water ice and other volatile compounds in permanently shadowed craters near the lunar poles. On Mars, the commission members observed, all the necessary oxygen, hydrogen, nitrogen, fertilizer, and methane needed to start a permanent settlement could be extracted from that planet's puny atmosphere. In one of the last papers he wrote before his death in 1992, Paine predicted that the processes needed to extract local materials would stimulate a new generation of industrial robots "with a hundred times the productivity of terrestrial factories."⁵⁷

Extraterrestrial colonies would allow the human race to leave "the precious and fragile planet where it was born," and extend life "to the far reaches of the inner Solar System," commission members maintained. Without expansion into space, humans remaining on a more crowded Earth would be forced to compete increasingly for limited resources, Rick Tumlinson argued nine years later. Nearly anything that a person on such an Earth wanted to do would be "something someone else cannot. . . . Equilibrium will be the goal of the state and individual freedoms will become ever more expendable." Space colonization would break this cycle, Tumlinson insisted. It would allow humanity to prosper and grow.⁵⁸

Engineers and enthusiasts debated the practical details of achieving the pioneering dream. Should humans work to establish a lunar colony or proceed directly to Mars? "Moon firsters" argued that the lunar colony would provide much-needed experience with the frontier technologies necessary to move farther from home.⁵⁹ Within ten years of the first landing, an industry task force observed, a community of one hundred pioneers could be living and working on the Moon.⁶⁰ Lunar settlers would explore their new home and set up scientific instruments such as a radio astronomy observatory on the back side of the Moon, shielded from interference from Earth. Like pioneers before them, they would look for ways to make their expeditions pay. Experts were especially intrigued by the possibility of mining the Moon. Solar flares, experts suggested, had deposited on the lunar surface quantities of helium-3, which could provide a rich source of fuel for fusion reactors, should that technology

ever take hold. One lunar booster argued that just sixty thousand pounds of helium-3 per year returned to Earth would satisfy the energy needs of the whole planet.⁶¹

To others, development of a lunar settlement seemed like a waste of time. The United States had been to the Moon. If the objective of a lunar base was to prepare for Mars, why not get on with the larger goal? In the spring of 1981 a collection of space-interest groups organized a conference at the University of Colorado in Boulder to examine whether "a manned Mars mission was a viable option for our space program."⁶² Out of the meeting emerged the so-called Mars Underground, a congregation of students, space boosters, and aerospace professionals devoted to making (as the title of a series of books supporting the concept revealed) *The Case for Mars*. More books and conferences followed.⁶³ In 1986 NASA joined the discussion with its own Mars conference and the following year established an Office of Exploration for the purpose of coordinating agency activities and convincing Congress and the president to approve the endeavor.⁶⁴

Much of the practical work contained in the various studies concerned the best way to get to Mars. In her 1987 report, astronaut Sally Ride proposed a series of three short sprints, with ten- to twenty-day stays on the planet's surface and an overall journey of no longer than a year. NASA engineers developed plans for more elaborate expeditions taking nearly three years. Debate led to government infighting. White House officials grumbled about conservative NASA bureaucrats and commissioned outside experts to develop more imaginative proposals. A deftly illustrated report by astronaut Thomas Stafford drew on suggestions from outside experts that nuclear propulsion could cut the one-way transit time to Mars from 224 to 160 days.⁶⁵

Amid the clamor and debate, the long-term goal remained steady. Humans would depart Earth, settle the Moon and Mars, and eventually move to the stars. A report from the Mars Underground predicted that the first human child would be born on Mars in the year 2020, when the population of the outpost reached one hundred persons. By 2081, authors of the chronology speculated, two hundred thousand colonists would live on Mars.⁶⁶

For all of its popular appeal, however, Mars remained a very inhospitable place. The 1976 Viking landers revealed a cold, dry desert with little atmospheric protection from sterilizing ultraviolet rays. Humans had not yet settled the Antarctic on Earth, which was absolutely balmy by comparison. How did Mars enthusiasts plan to handle the hostile environment on Mars? No problem,

they replied. They would simply transform the planet into an Earth-like environment by altering conditions there. Of all of the recommendations for pioneering space, few were as imaginative as the proposals for terraforming Mars.

Terraforming was once the preserve of science fiction writers. In the April 1937 issue of *Astounding Stories*, Ross Rocklynne described a successful attempt to move fifty-two-million cubic miles of frozen water from the asteroid belt to Mars.⁶⁷ A series of stories published under the pseudonym Will Stewart in the 1940s explained the use of “paragravity generators” to attach atmospheres to previous lifeless bodies. Stewart, whose real name was Jack Williamson, gave the process the name that has remained with it since.⁶⁸ In 1950 Robert Heinlein described the terraforming of Ganymede, one of the giant moons of Jupiter, by several thousand colonists from planet Earth.⁶⁹

In 1961 the young Carl Sagan published an article in *Science* magazine containing a plan for making Venus habitable, one of the first serious proposals for altering the environment of planets. Although Sagan’s plan was flawed (he overlooked the problems posed by the density of the atmosphere), the article gave scientific respectability to the concept.⁷⁰ By 1975 NASA was ready to give its official blessing, sponsoring a study that examined the possibility of altering the Martian environment to make it more habitable.⁷¹ The advocacy group Mars Underground was born out of the interest of people anxious to explore and transform that planet.⁷²

The concept continued to draw public interest. In May 1991 *Life* magazine ran a cover story on the subject of terraforming Mars. Relying upon scientific opinion, the editors presented an ambitious 150-year scheme for transformation of the cold, dry planet. Orbiting solar reflectors would melt the polar ice caps, and Martian factories would produce greenhouse gases and ozone substitutes. As the planet warmed, nitrogen and water would seep out of the Martian soil, and the atmosphere would thicken. This in turn would cause further warming. Clouds would appear, and the color of the sky would shift from pink to blue. Oxygen for the newly forming atmosphere could be extracted by local factories from carbon dioxide, carbonate rocks, and deposits of iron oxide. Pioneers would plant tundra plants and hearty evergreens as the mean planetary temperature approached the freezing point of water. Rain would fall and agriculture would thrive, but the maturing atmosphere would need more oxygen to allow humans and animals to live outside. With enough oxygen-producing factories and vegetation, the editors predicted, the planet could be made totally suitable for human habitation by the year 2170. Streams, lakes, and oceans

would cover the surface of a new moist green globe.⁷³ To celebrate the achievement, artist Robert McCall prepared a painting depicting pioneers deep in a Martian canyon emerging from glass-domed biospheres as cannons in the background pump greenhouse gases into a newborn atmosphere. Touches of green, tundralike vegetation appear on nearby hills as temperatures rise. The inspirational painting, titled *Terraforming Mars*, hung for many years outside the NASA administrator’s office in Washington, D.C.

The cost of making Mars fit for human habitation would be high, but not beyond the reach of technologically advanced nations. *Life*’s editors optimistically predicted that investment costs for their terraforming proposal would peak at \$45 billion per year during the early buildup stage—an impressive sum but a fraction of what earthly nations spend annually on national defense or government-assisted health care. The technical problems would be formidable, but not insurmountable. Engineers would need to develop inexpensive rocket ships and cheap sources of energy (fusion reactors would help considerably). With much fine-tuning and the avoidance of undesirable side effects, it could be done. As Carl Sagan observed, “We need look no further than our own world to see that humans are now able to alter planetary environments in a profound way.”⁷⁴

On 20 July 1989, to commemorate the twentieth anniversary of the first landing on the Moon, President George H. W. Bush challenged the United States to commit itself to a sustained program of exploration that would lead to the settlement of space: “From the voyages of Columbus—to the Oregon Trail—to the journey to the Moon itself—history proves that we have never lost by pressing the limits of our frontiers.” To begin the process, he called upon Congress to join him in supporting an outpost on the Moon and the first human expedition to Mars. In a later speech he set a goal of 2019 for the first Mars landing.⁷⁵ When NASA’s cost estimate for the venture soared, members of Congress refused to fund the efforts, a response the first President Bush characterized as an act of short sightedness by people who lacked vision.⁷⁶

President George W. Bush tried again in 2004 when he announced a program to return to the Moon and send humans to Mars. Referring to the expedition led by Meriwether Lewis and William Clark two hundred years earlier, the second President Bush noted that the United States undertook that journey “to learn the potential of vast new territory, and to chart a way for others to follow.” For the same reasons, Bush announced, Americans would return to the Moon by 2020. “With the experience and knowledge gained on the moon,” he

continued, "we will then be ready to take the next steps of space exploration: human missions to Mars and to worlds beyond."⁷⁷ This time NASA officials struggled to fund the effort from their existing budget without exponential growth, without success.

The United States and the other nations of the world may achieve these goals. It is technically feasible and not beyond the financial reach of nations rich enough to fly in space. Yet even if it occurs, would a human presence on Mars accomplish the broader goals contained in the exploration vision?

The image of the frontier is America's creation myth. For many (but not all) Americans, it explains where they came from and why they are special among the peoples of the world. According to this story, America was essentially an unoccupied land of boundless opportunity. Hardy, independent pioneers settled the wilderness through their own ingenuity and resources and created a new civilization. Unencumbered by old traditions, they formed simple democratic communities with governments that became a model for the entire world. Their inventiveness led to the richest and most technologically advanced nation in human history. The work was hard but satisfying. Generation after generation repeated this experience until the frontier was gone. The impulse to explore and settle remained in American culture, however, waiting to be reapplied on some new frontier.⁷⁸

For all of its cultural appeal, the image, alas, is factually wrong. It is based upon a romanticized interpretation of history as far removed from reality as the Buffalo Bill Wild West Show was from the real events it sought to portray. The American West was not an empty land waiting to be settled, as the native Americans and Hispanics who already lived there knew. Settlers depended extensively upon subsidies and capital provided by people from more settled regions for activities such as railroad transportation, dam building, and irrigation. In business enterprises such as the gold and silver rushes, failure was as common as prosperity. The economic principles that favored the formation of large companies employing low-wage workers were not suspended in the West. Territorial governments were no less corrupt nor more democratic than those in the East, and as many principles of democracy emerged from the pens of intellectuals residing in the eastern United States and Europe as from the frontier experience.

If space is like the real frontier, what might the experience tell us? As people who have labored in the enterprise already know, space travel can be hard and dangerous work. Spacecraft and space stations can be noisy, crowded, even foul

places filled with temperamental equipment. Long voyages under such conditions can encourage thoughts of homicide. In that sense, human space travel may not be much different from life on an actual frontier. "Nobody wants to be a cowboy," lamented one western employment specialist. "It's hard work, it's dirty work, it's round-the-clock work." It is something most Americans want to watch from a distance.⁷⁹

Frontiers are rarely utopian in spite of efforts of their advocates to portray them as such. Commenting on the challenges of founding a lunar colony, Thomas Paine assured his supporters that it would "sweep aside old world dogmas, prejudices, outworn traditions, and oppressive ideologies." Konstantin Tsiolkovsky predicted that in space colonies "human society and its individual members [would] become perfect." Gerard O'Neill predicted that life in his suburb-like colonies would permit "most of the human population to escape from poverty" and that the environment would "be optimized for good health."⁸⁰ By their apparent openness and lack of rules, frontiers attract utopian thinkers. History suggests, however, that new settlers bring society and all its imperfections with them. Utopian communities commonly fail because they cannot escape the human traits their founders wish to leave behind.⁸¹

The harsh conditions on imagined new worlds may pose additional challenges. Utopians see in new places the opportunity to construct communities free of the old. Local conditions can obstruct this dream. The extraterrestrial community into which explorers emerge after traveling through the portal in the widely viewed science fiction film *Stargate* is an oppressive despotism drawn from the ancient civilization that built the Egyptian pyramids. Luke Skywalker's foster parents are killed by Imperial Stormtroopers on the wild west and largely ungovernable planet of Tatooine. Significantly, both of these imagined spheres present dry environments like those found on the planet Mars. A particular theory of developing civilization suggests that settlements arising under acutely arid conditions give rise to despotic and bureaucratic governments because forced labor and strict rules are necessary to regulate the distribution of water.⁸²

The general term for such a community is dystopia—a version of society characterized by oppression, misery, and undesirable living standards. Science fiction offers many examples, from George Orwell's classic *1984* to the failed attempt to create a utopian community in Aldous Huxley's *Brave New World* (technically an anti-utopia). The challenges of maintaining an extraterrestrial outpost on a largely airless and water-scare world might create conditions

favoring highly regulated, autocratic governing bodies that are more corporate than democratic in form. In America, frontiers are thought to promote equality, independence, and freedom, but on the Moon or Mars the opposite might be true. In advance, it is hard to know.⁸³

Frontiers are also a metaphor for ungrateful dependence. American colonists depended upon British troops for protection from the French and their Native American allies and were notoriously reluctant to pay their share. When the British imposed the Stamp Act as a means to recover their investment, American colonists organized the boycotts and demonstrations that led to war. One century later, eastern taxpayers and financiers invested heavily in the development of the American West. How will Earthlings react when space pioneers demand outside investment for their extraterrestrial colonies while complaining about outside rule? Will people on Earth glorify the independence of these space age pioneers or treat them like ungrateful children?⁸⁴

In spite of the relentless attacks of classroom historians, the romantic image of the frontier endures among the public at large. Many people continue to believe in it. Space advocates call upon the popular image of the frontier to garner support for their visions, even as historians attack them. The space frontier is an appealing analogy to many people in the United States, given its pioneering history. The American creation myth provides a level of vindication for space exploration that compensates for less-glamorous byproducts. It is doubtful that Americans would pay hundreds of billions of dollars to send humans to Mars simply to gain some technology spinoff or to establish the interplanetary equivalent of an Antarctic research station. The frontier analogy, with all of its flaws, allows people to believe that space exploration will reopen one of the longest and most formative chapters in American history. Never mind that the reality of space colonization may differ considerably from the popular image of it. Space flight is a dream, and dreams do not have to be entirely real in order to motivate behavior.

The Moon and Mars and other places could be explored for the purposes of scientific understanding by robots and machines alone. To do so, however, would fail to satisfy one of the central elements of the spacefaring dream—the extension of humanity into the extraterrestrial realm. Listen again to the words of Carl Sagan, set down in the book *Pale Blue Dot*, shortly before his death. Sagan traced the spiritual erosion of modern life to two great developments. The first was the closing of terrestrial frontiers. We are all wanderers, he maintained, from Ice Age humans who crossed the Bering Straits to Polynesian ar-

gonauts in outrigger canoes and American pioneers: "This zest to explore and exploit . . . is not restricted to any one nation or ethnic group. It is an endowment that all members of the human species hold in common."⁸⁵ Humans, Sagan continued, first wandered as hunters and gatherers and continued to migrate as explorers and pioneers. Only recently, for a brief period in the lineage of the species, have humans confined themselves to established settlements. In spite of the material advantages to be found in villages and towns, humans remain restless. "For all its material advantages," Sagan professed, "the sedentary life has left us edgy, unfulfilled." Humans have not lost their urge to roam: "The open road still softly calls, like a forgotten song."⁸⁶

Sagan suggested that the urge to move on is necessary to survival, an instinctive drive built into human behavior as a result of natural selection. Towns and villages do not last forever, and the people who crave new places protect their descendants against the catastrophes that inevitably befall those who remain behind. The human experience has been diminished by this loss of openness, Sagan suggested, not just among Americans lamenting the loss of the Western frontier but among humans everywhere.

Joining this restlessness of place, Sagan suggested, is a new desperation of spirit. For centuries humans took comfort in the knowledge that the Earth sat at the center of the universe, that the Sun and Moon and stars rotated around the Earth, and that God had created humans in His own image for a special purpose. Science devastated those beliefs. Earth is a tiny blue dot rotating around an inconspicuous yellow star on the outer reaches of one of a hundred billion galaxies. There are certainly other planets, probably housing other life-forms, and possibly other universes that operate according to different laws of nature. According to Sagan, the best available evidence does not support the need for a Grand Designer.

"Human beings cannot live with such a revelation," Sagan quoted British journalist Bryan Appleyard as saying.⁸⁷ The great demotions, as Sagan called them, have created a more mature view of nature, but they have also devastated the human spirit. Maturity is painful; it is easier to think like a child. In the past, when humans believed themselves part of a greater purpose, they could accept moral codes passed down from people presenting themselves as the worldly agents of the creator. Humans could follow the exhortations of religious and secular authorities. The apparent insignificance of the Earth in the cosmos weakened those codes. It is difficult for humans to respect strict moral codes when those doctrines are based on patently false cosmologies. The

new view of the universe has undermined the leadership of religious and secular authorities and bred a sense of hopelessness.

Against this sense of desperation, Sagan believed, a new spirit of discovery could arise. The very science that created the sense of despair could create a new state of wonder: "Once we overcome our fear of being tiny, we find ourselves on the threshold of a vast and awesome Universe that utterly dwarfs—in time, in space, and in potential—the tidy anthropocentric proscenium of our ancestors." For the immediate future, Sagan thought, humans could do their investigating from the Earth. Yet a time would come when humans would move out from the planet. Their instincts and survival demanded it. "On behalf of Earthlife, I urge that, with full knowledge of our limitations, we vastly increase our knowledge of the Solar System and then begin to settle other worlds."⁸⁸

7

Stations in Space

I think if you ask the public at large, and quite possibly most of the people within NASA, what a space station was, they would think in terms of the movie that came out fifteen or twenty years ago.

— John Hodge, 1983

Having created an imaginative vision of humans leaving Earth and settling space, devotees faced the practical difficulties of actually doing so. An essential step in practically every settlement or exploration scheme was the creation of a permanent facility in an orbit above the Earth at which humans could live and work. Such a station, as it was called, provided a mechanism for completing the activities humans imagined taking place in space. Unfortunately, those activities gathered together on a single faculty tended to conflict with one another, exacerbating the practical difficulties of actually constructing one.

In the centuries preceding the space age, nations seeking to extend lines of exploration and settlement built the terrestrial equivalent of space stations across the face of the Earth. Frontier forts, way stations, trading posts, and base camps provided convenient means for advancing human presence into unconventional territory. Colonists and pioneers, mountain climbers and

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112. *Congressional Record*, 22 September 1993, S12152. See also Mariane K. Meuse, "Space Explodes! Alien Media Invades Earth," *Ad Astra*, January–February 1992, 42–46, 55.
113. See Michio Kaku, *Hyperspace: A Scientific Odyssey through Parallel Universes, Time Warps, and the Tenth Dimension* (New York: Oxford University Press, 1994), 196–201; George Smoot and Keay Davidson, *Wrinkles in Time* (New York: William Morrow, 1993), 83–86; NASA, *NASA Facts*, "COBE Observes Primeval Explosion," Goddard Space Flight Center, Greenbelt, Maryland, n.d.
114. Craig Covault, "Cosmic Background Explorer to Observe Big Bang Radiation," *Aviation Week & Space Technology*, 6 November 1989, 36–41.
115. Quoted from Paul Hoversten, "Relics of Universe's Birth Found," *USA Today*, 24 April 1992; and Thomas H. Maugh, "'Holy Grail' of the Cosmos," *Los Angeles Times*, 24 April 1992, Washington ed.
116. Malcolm W. Browne, "Despite New Data, Mysteries of Creation Persist," *New York Times*, 12 May 1992, sec. C, pp. 1, 10; NASA, "Cosmic Background Explorer Observes the Primeval Explosion," Goddard Space Flight Center, Greenbelt, Maryland, n.d.
117. Kathy Sawyer, "Big Bang 'Ripples' Have Universal Impact," *Washington Post*, 3 May 1992, sec. A, p. 1.
118. Hoversten, "Relics of Universe's Birth Found." Also see Billy Goodman, "Ancient Whisper," *Air & Space*, April–May 1992, 55–61.
119. Campbell, *The Power of Myth*.
120. Genesis 1:3–5.
121. Sawyer, "Big Bang 'Ripples' Have Universal Impact," sec. A, p. 20.
122. H. G. Wells, *The Time Machine* (New York: Berkley, 1963). George Pal released the motion picture version in 1960. Pal, *The Time Machine* (MGM, 1960).
123. See Paul J. Nahin, *Time Machines: Time Travel in Physics, Metaphysics, and Science Fiction* (New York: American Institute of Physics, 1993); Peter Nicholls, ed., *The Science in Science Fiction* (New York: Knopf, 1983), chap. 5.
124. NASA, "Frontiers in Cosmology," Hubble Space Telescope Fact Sheet, Space Telescope Science Institute, Baltimore Maryland, n.d., NASA History Office.
125. Lockheed Missiles and Space Company, "Hubble: A Window into the Universe," 1986. See also NASA, "Hubble Space Telescope Media Reference Guide," published for NASA by Lockheed Missiles and Space Company, Sunnyvale, California, 1990; Joseph J. McRoberts, *Space Telescope*, NASA EP-166 (Washington, D.C.: GPO, n.d.). All in NASA History Office.
126. Steven Spielberg, Bob Gale, and Neil Canton, *Back to the Future* (Universal Studios, 1985).
127. Kaku, *Hyperspace*, x (emphasis removed). Also see Kaku and Jennifer Trainer, *Beyond Einstein: The Cosmic Quest for the Theory of the Universe* (New York: Bantam Books, 1987); and Hawking, *Brief History of Time*.
128. Kip S. Thorne, *Black Holes and Time Warps* (New York: W. W. Norton, 1994); Barry Parker, *Cosmic Time Travel: A Scientific Odyssey* (New York: Plenum Press, 1991).
129. Michael S. Morris, Kip S. Thorne, and Ulvi Yurtsever, "Wormholes, Time Machines, and the Weak Energy Condition," *Physical Review Letters* 61 (26 September 1988): 1446–49; Michael S. Morris and Kip S. Thorne, "Wormholes in Spacetime and Their Use

- for Interstellar Travel," *American Journal of Physics* 56 (May 1988): 395–412. See also, Nahin, *Time Machines*, tech note 9.
130. Lewis Carroll, *Through the Looking Glass* (New York: Grosset and Dunlap, 1946); C. S. Lewis, *Lion, the Witch and the Wardrobe* (New York: Collier Books, 1950).
131. NASA, News Release 95-216, "Hubble Finds New Black Hole and Unexpected Mysteries," 4 December 1995.
132. Kaku, *Hyperspace*, chap. 10.
133. Patrick J. Kiger, "The New Galileo," *Baltimore Magazine*, February 1990, 107.
134. *Congressional Record*, 24 June 1993, H4057. See also *Congressional Record*, 23 June 1993, H3974–78, and 19 October 1993, H8114–24; and *Congressional Record*, 10 July 1991, S9430–43.
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CHAPTER 7: Stations in Space

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