INTRODUCTION

Mars is essentially in the same orbit [as Earth] . . .
Mars is somewhat the same distance from the Sun, which
is very important. We have seen pictures where there are
canals, we believe, and water. If there is water, that means
there is oxygen. If there is oxygen, that means we can
breathe.—VICE PRESIDENT DAN QUAYLE,
August 11, 1989 (quoted in David
Grinspoon, *Venus Revealed*)

WHY MARS?

For well over a century, Mars has been at the center of scientific and philosophical debates about humankind's place in the cosmos. Since Giovanni Schiaparelli announced in 1878 that he had observed *canali* (channels or canals) crisscrossing its surface, the planet has been the subject of thousands of scientific articles, dozens of full-length studies, and the setting for hundreds of science-fiction novels, stories, and movies. A century before Schiaparelli, astronomers had begun to explain the seasonal changes they observed on Mars in terms of what they knew about the climate and biology of Earth. Although specific analogies between the two planets have changed dramatically since then, scientists still frequently resort to terrestrial analogies to describe Mars. Over time, such analogies have reflected changing conceptions of both worlds: while Mars has been perceived through the lenses of terrestrial sciences, the study of the red planet has shaped, and continues to shape, humankind's understanding of Earth. Since the height of the canal controversy a century ago, lessons extrapolated from, or imposed on, Mars as a "dying planet" have been invoked to support competing, even antithetical, views of the fate of our world and its inhabitants: a glorious future of techno-scientific progress or an irrevocable fall into environmental devastation, social chaos, and eventual extinction. Simply reading the titles of some of the scientific studies and science-fiction novels published during the last century—*Mars as the Abode of Life, Mars Beckons, Destination Mars, Mapping Mars, Outpost Mars, Red Mars, Green Mars,* and *Blue Mars*—seems to invite us to explore the persistence of the red planet in our cultural imagination. Even as orbiters and landers continue to explore its surface and atmosphere, Mars still dominates our daydreams of interplanetary colonization and haunts our nightmares about invaders from outer space.

Dying Planet explores the ways in which Mars has served as a screen on which we have projected our hopes for the future and our fears of ecological devastation on Earth. It draws on work in planetary astronomy, the history and cultural study of science, science fiction, literary and cultural criticism, ecology, and astrobiology to offer a cross-disciplinary investigation of changing perceptions of Mars as both a scientific object and a cultural artifact.[1] Even in 2004, as scientists pour over gigabytes of data from ongoing NASA and European Space Agency (ESA) missions, the red planet seems as dynamic, complex, and intriguing a world as it did a century ago when the *New York Times* and other newspapers routinely ran stories about its canal-building inhabitants. In tracing the history and analyzing the significance of our cultural fascination with Mars, I have three primary goals: to describe and contextualize important scientific debates about the planet; to explore the reasons for its tenacious hold on the scientific and popular imagination; and to analyze the dynamic interactions among planetary science, science fiction, and other disciplines, notably ecology, that have kept Mars on the front pages since the 1800s. The paths to these goals frequently intersect, and one of my purposes is to suggest that in order to make sense of current scientific thinking about Mars, we need to understand a complex sociocultural history that has cast the planet as a harbinger of the ecological fate of the Earth.

My title, "dying planet," was used for half a century to characterize Mars and to sum up its relationship to Earth. This label dates from the work of nineteenth-century astronomers, though it was popularized between 1912 and 1948 by Edgar Rice Burroughs in the eleven novels that take place on the planet he calls Barsoom. Yet long before Burroughs began writing, Mars occupied a unique place in the Western imagination, and many studies of the planet begin with a simple but important question: Why Mars? Why has the planet haunted our collective imagination and why has it been, far and away, the favorite site for interplanetary science fiction since 1880? (Markley et al. 2001; Godwin 2000: 210–11; Hartmann 2003, 4–6).[2] One answer is that Mars has proved to be the most interesting object in the night sky for earthbound observers since the invention of the telescope in the seventeenth century. The twenty-six-month cycle that brings the red planet within thirty-four million miles of Earth (as it did in summer 2003) has provided tantalizing glimpses of a world that bears some striking similarities to our own. Although Venus is closer to Earth and now seems, to some planetologists, more earth-like than Mars in its atmospheric and geological cycles, it is covered by dense, acidic clouds; its atmosphere only recently penetrated by space probes and radar to map its hellfire, 850 degree surface (Grinspoon 1997, 143–48). Mars, on the other hand, displays features that have been seen and sketched since the 1600s, notably the polar caps that wax and wane and the wave of darkening (the result of seasonal albedo changes) that spreads across the planet from the poles toward the equator during its spring and summer months.[3] Although the surface of Mars is difficult to see clearly through the dense and turbulent atmosphere of Earth, its dark patches and polar caps historically have suggested powerful, seemingly self-evident, analogies between the two planets. The very limitations of earth-based observation have provoked both painstaking study of the planet's surface and rampant speculation based on analogies to Earth's seasonal and hydrological cycles (Sheehan 1996; Hartmann 2003, 66).

During the last forty years, however, the data and photographs returned by spacecraft have revealed a world that poses complex questions about its history and composition. The oldest terrain on Mars preserves landforms three to four billion years old that provide a window into a geological past that has long since disappeared from Earth. The surface of Mars has been photographed with increasing precision and sophistication since Mariner 4 returned nineteen wide-angle black-and-white images in 1965, and each successive array has provoked a rethinking of fundamental assumptions about the planet as well as aesthetic and even (in the broadest sense) religious responses that border on what we might call the interplanetary sublime. Mars has the largest volcano in the solar system, Olympus Mons, which covers a territory the size of Arizona and rises thirteen miles above the datum (the Martian equivalent of sea level), and the Valles Marineris, a fault system that stretches for three thousand miles, dwarfing terrestrial analogues and making the Grand Canyon seem "a mere crack in the sidewalk" (Hartmann 2003, 315). Yet the spectacular landforms that bear witness to the planet's geophysical history are only part of a dynamic mosaic that scientists are trying to piece together. Orbital photographs show evidence of geologically recent lava flows and patterns of water erosion, indicative of processes that still may be occurring. The data returned since 1997 by the Mars Global Surveyor, Mars Odyssey, ESA orbiter, and the Mars Exploration Rovers have left scientists trying to reconcile seemingly incommensurate views of the planet and its history: a frozen snowball that has experienced only brief periods of warming versus a once warmer and wetter Mars that is still changing—resurfaced by volcanism, meteorite impacts, water and ice erosion, wind, and the effects of periodic climactic instabilities. Current scientific debates about Mars hark back to controversies that have existed, in a variety of forms, since the eighteenth century, and the historical, epistemological, and cultural implications of these debates are, in an important sense, the subject of my study.

With the advent of increasingly sophisticated technologies to collect and analyze data, analogies between Mars and Earth have become far more complex than they were even a quarter century ago. William K. Hartmann's excellent overview of the current (as of 2003) scientific understanding of Mars includes a dozen photographs he has taken of Mars-like analogues on Earth, from desert terrain in northern Mexico to gullies on volcanic hillsides in Iceland. As a planetary scientist, Hartmann describes the surface of Mars in terms of geological time; "recent" gullies, for example, may have been formed within the last ten million years. As a writer of science fiction, however, Hartmann deals with an imagined near-future, which brings Mars within the semiotics of historical and experiential time. This productive tension between geological and human time scales informs his photographs of Martian analogues on Earth. When he asks his readers to imagine what "a future party of astronauts" would see from the "summit of Olympus Mons," he is drawing on a complex fictional tradition in which the Martian landscape triggers a rethinking of the relationships between humankind and its environment(s) (Hartmann 2003, 313). Hartmann's invitation to his readers to imagine looking across the calderas of the solar system's largest volcano underscores the ways in which Mars exists as a complex multidisciplinary object.

To describe Mars as a "multidisciplinary object" is both to call attention to the historical, epistemological, and cultural relationships that I invoked above and to insist on the importance of the scientific debates that the planet has generated. Situating these debates within their historical and theoretical contexts is essential to understanding why any answer to the question "why Mars?" invariably crosses disciplinary boundaries. The study of the planet typically involves teams of scientists and engineers, who are needed to instrument experiments, collect data, interpret that data, and then contextualize the results and suggest their significance. Although almost all large-scale research projects in the sciences now involve multiple investigators, the interdisciplinary nature of planetary research involves complex interactions among specialists in various disciplines, including geology, chemistry, hydrology, meteorology, and microbiology. While researchers can obtain some provisional answers to specific questions about, say, the mineral composition of specific areas of the Martian surface, these answers invariably provoke new questions that, in turn, impinge on other disciplines, epistemologies, and discourses. As I suggest throughout this study, scientific debates about Mars since the canal controversy usually involve clashes between different disciplinary ideas about research protocols, the interpretation of evidence, and the nature of scientific reasoning: what is one researcher's legitimate inference about Mars is another's example of imprudent guesswork.

Precisely because it has generated such controversies, Mars has been at the center of the emerging, multidisciplinary science of comparative planetology—and of the still virtual sciences of exobiology and terraforming. These virtual sciences pose the big-ticket questions that both develop from and intrude on scientific discussions about the planet: Is, or was, there life on Mars? Can humankind colonize the planet and transform its forbidding landscape into a habitable biosphere? If so, when? In turn, these speculative questions have led scientists to reconsider theories about planetary formation and the origins and development of life. The very structure of analogy itself encourages the question posed by Hartmann's imagined astronauts: Where do we fit in?

This question has cultural, philosophical, and scientific dimensions and, by its very nature, encourages frequent crossings of the boundaries between science and science fiction. Hartmann's fictional climbers on Olympus Mons represent one strategy of trying to bring the billion-year time scales of Martian geological history within the imaginative frame of embodied experience, but they also testify to the desire to comprehend the vastness of planetary history. Since Schiaparelli, astronomers have attempted to extrapolate from what they know about Earth's climate and geological history to what they can surmise about conditions on Mars. Working within a set of scientific assumptions that still retain some currency, scientists in the 1880s and 1890s reasoned that since Mars was a smaller planet than Earth its molten core and then its surface would have cooled more quickly, and oceans would have formed soon afterward. Mesmerized by Darwinian theory, Percival Lowell and many of his contemporaries argued that life would have developed on Mars sooner than it did on Earth and also would have evolved more rapidly. But the geothermal engine on this smaller world would have run down more quickly, and, as the red planet cooled, it would have lost its oceans and much of its atmosphere. Evolutionary logic then suggested that any beings who could survive on this dying planet might far surpass humans in intelligence and be able to marshal their dwindling resources to stave off extinction. Even Lowell's critics accepted the broad outlines of this evolutionary theory and appropriated the metaphor of a dying world to describe their views of a Mars without canals. This quest to understand the vast time scales of planetary development has been at the forefront of comparative planetology since Lowell's time, and his canal theory owed much of its popularity to his skill in relating an impersonal geological history to the compelling picture he evoked of the struggle for existence on a desert world. In this respect, the canals allowed Lowell's readers to meditate on relationships between the human experience of scarcity and the larger cosmic forces that, in the late nineteenth century, seemed to indicate that Earth was "going the way of Mars" (Lowell 1909, 122). To imagine gazing across the Martian landscape in 1905 or 2005 is to confront the possibility that one is looking, in some still-to-be-defined way, at the future of the human species.

As the canal controversy demonstrates, the fascination with extraterrestrial life and, more broadly, extraterrestrial ecologies lies at the heart of humankind's obsession with Mars. The exploration of Mars as the site of past or present life, says Chris McKay of NASA-Ames, is a "fundamental science driver" for future exploration (Markley et al. 2001, "interviews" 5). Historically, questions about life on Mars have been bound up with changing scientific ideas about the limit conditions for terrestrial biology. In different ways, the science teams studying the possible nanofossils in Mars meteorites are asking more precise and more complex versions of questions debated by Lowell and his critics: Is the environment on Mars too harsh to support indigenous forms of life? If it exists or has existed in the past, could Martian biology be fundamentally different from life on Earth? To pose, try to answer, or reframe these questions is to realize that exobiology—the study of life beyond the Earth's biosphere—remains both a virtual and syncretic science. Like comparative planetology, the search for life on Mars is a collaborative effort based on intersecting specialties and subspecialties that together can offer only heuristic answers. The search for Martians since the 1890s has proved immensely controversial because the conclusions drawn, like the questions posed, depend on often competing assumptions about exobiology and the technologies and protocols that can be used to establish or rule out its existence. Nonetheless, the assertion that the discovery of life on Mars or elsewhere in the universe will alter profoundly humankind's perception of its place in the cosmos is an extraordinarily common one. Without disputing its significance, I suggest that this fascination with exoecologies rests on a host of extrascientific values and assumptions—at once theological, philosophical, social, and cultural. To explore these values and assumptions is to offer an ongoing narrative in response to the question, "Why Mars?" and to rethink the meaning of some key terms that invariably recur in discussions of the red planet: analogy, methodology, and history.

ANALOGIES AND METHODOLOGIES

Areology, the study of Mars, is defined by intersecting research programs: the coordination (and conflicts) among various disciplines (climatology, hydrology, petrology, extremophile biology, and chemistry); different experimental styles and practices; and different rhetorical and conceptual traditions. Most planetologists, whatever their philosophical leanings, emphasize the limitations of current knowledge about the planet. As Kevin Zahnle observes: "In some ways the debate [about Mars and the possibility of life] has really moved little since the days of Flammarion and Lowell. The most interesting information remains right at the limits of resolution, be it metres in satellite images of gullies, or nanometres in microscopic images of magnetite crystals. Always life on Mars seems just beyond the fields that we know" (2001, 213). The data on Mars, as Zahnle suggests, remains a partial mosaic that leads scientists to rely on what Victor Baker calls "analogies of form and context" between Earth and Mars to explain the latter's surface features. Rather than leading to hard and fast conclusions, however, such analogies, Baker argues, "suggest fruitful working hypotheses, thereby leading to completely new theories that bind together any newly discovered facts" (2001, 228). Even if such hypotheses may strike many in the scientific community as "outrageous," he continues, "it is the productive pursuit of such hypotheses that leads ultimately to new understanding, not only of Mars, but also of Earth" (228). Baker's "productive pursuit" is an ongoing process; new theories and newly established facts are dynamically as well as dialectically related.

His emphasis on the value of Mars for understanding Earth underscores the close connections that have evolved between ecology and areology. The study of both planets has moved from being governed by deterministic metaphors to a recognition that "multiple causal pathways" (Lewontin 1991, 147) have shaped their surfaces, atmospheres, and potential as life-bearing worlds (Bell 2003, 34–41; Zuber 2003, 42–48).

Scientific analogies between conditions on Earth and Mars, as Hartmann and Baker suggest, cut in two directions, and one of the reasons for this divide has to do with the nature of analogical thinking itself. Analogies have significant consequences in science, social science, and literary studies because they disrupt analytical methods based on the application of accepted principles to specific examples; analogical thinking, Ronald Schleifer argues (2000, 13-15), involves a reciprocal process of negotiation between two terms or objects. Because it works by induction, a point-by-point comparison of observed characteristics or phenomena, analogical thinking has the potential to call into question the very principles that allow such comparisons to be made.

Schleifer's discussion of analogy is helpful in understanding the dynamic interchanges that structure historically the relationship between Earth and Mars. Not surprisingly, even as Mars has been perceived and described scientifically as an earthlike planet, Earth has become, in effect, a Mars-like planet. One of the consequences of this analogical relationship has been an increasing wariness about assuming that the Earth represents general principles of planetary evolution and the ideal "solution" to the problems of sustaining a viable biosphere. The "danger of having so much planetary science grow out of the field of earth science," David Grinspoon argues, "is that we may be overly predisposed toward 'geocentric' interpretations: we sometimes assume Earth to be the standard against which other planets are measured, rather than simply one among many possible outcomes of planetary evolution." For this reason, over the course of the last century "the growth of planetary science has also produced an enlarged, less provincial perspective on Earth" (1997, 57). Bedrock conceptions of what a planet is have been called into question, and scientists have been forced to justify their assumptions and reasoning: comparative planetology frames questions that cannot be asked from a parochial perspective. This "less provincial perspective" about the geochemical history of the planets also suggests a questioning of fundamental assumptions about ecology; the range of conditions—available nutrients, energy sources, chemical reactions, water, and temperatures—under which life can exist.

In the multidisciplinary context of comparative planetology, Mars has become a bellwether in both scientific and broader cultural debates about the nature, legitimation strategies, and aims of science. Because planetary science is inductive and heuristic, it resists the all or nothing assertions, the "epistemological absolutism" (Shapin 1999, 13) that too often dominates, and impoverishes, debates in the philosophy of science (Smith 1997, 243–66; Markley 1999a, 47–70; Plotnitsky 2002). In describing the "cultural clashes within the hybrid discipline of planetary science," Grinspoon argues that "equations, and the conclusions they lead us to, are only as good as the assumptions that go into them" (1997, 173). Rather than deductive models based on mathematical predictions, planetary scientists characteristically offer inductive and heuristic accounts of probable interpretations of the available evidence, even as "cultural clashes" among astronomers, chemists, geologists, and microbiologists reflect often very different ideas of the reliability and significance of particular data and of the values and assumptions that underlie different disciplinary models of knowledge.

In an important challenge to the regime of "epistemological absolutism," biologist Richard Lewontin offers a historicist account of the methodologies of scientific inquiry: "If one examines science as it is actually carried out," he asserts, "it becomes immediately clear that the assertion that it consists of universal claims as opposed to merely historical statements is rubbish" (1991, 142). Lewontin maintains that even agreed-on, widely practiced methodologies are culturally and historically situated. In his view, scientific truth-claims have complex internal structures and complicated networks of external affiliations that cannot be explained solely by reference to internal standards of legitimation. Significantly, Lewontin's description of the contingency of representations of the physical universe suggests why he shares a heuristic vocabulary with practitioners of the cultural study of science, including Donna Haraway, Michel Serres, Bruno Latour, Steven Shapin, Katherine Hayles, and many others.[4] In different ways, these cross-disciplinary researchers are concerned with investigating what Andrew Pickering (1995) calls "the mangle of practice" and the contingent languages of scientific debate rather than with seconding or attacking specific pronouncements about the nature of "reality."

In discussing the ongoing controversy over the possible nanofossils in Martian meteorite ALH84001, Hartmann contrasts the operations of science to the discourses of persuasion, marketing, and competition that dominate popular media. Science, he argues, "works . . . by appeal to evidence. In ideal science, the glory goes . . . to the person who brings the best data to the table. All the data are spread out, and the best estimate of truth emerges from it, not from the rhetoric of the person who makes the best case" (2003, 267). The crucial terms in Hartmann's description—"ideal science" and "best estimate of truth"—do not suggest a hard-and-fast opposition between "evidence" and "rhetoric" but rather processes of negotiation, debate, and deliberation by which an "ideal" consensus can be reached. In practice, the "best estimate of truth" becomes generally accepted only by sorting through and debating exactly what constitutes "the best data," and new data invariably provoke more discussions and eventually a new, always provisional, consensus. As the current controversy about Martian nanofossils suggests, stalemates not only occur with regularity, they often result in bitter disagreements, including confrontations that Hartmann describes "where nominally fair-minded researchers . . . traded accusations of inept science [and] shook with red-faced rage" (266). The cultural study of science is interested in such debates not to glorify the "winners" and ridicule or explain away the "losers" but to investigate the ways in which consensus views have been debated, established, modified, and overturned. To a great extent, scientists and laypersons come to trust certain analyses precisely because both methodologies and conclusions have been subject to such scrutiny and revision.

The two parties of red-faced scientists that Hartmann describes cannot agree about the likelihood of nanofossils in meteorites because (as I suggest in chapter 8) they are relying on different methodological assumptions and different conceptions of probabilistic "proof." Such debates indicate why Lewontin insists that "facts in science do not present themselves in a preexistent shape. Rather it is experimental or observational protocol that constructs facts out of an undifferentiated nature" (1991, 147). "Constructs" in this sentence does not mean "make up out of whole cloth"; instead, the verb calls attention both to the practice of science (the designing, building, testing, and calibrating of instruments; experimental and observational protocols; running and rerunning trials; writing and rewriting papers) and to the complicated negotiations that go into producing a consensus about the "best data" and its significance. This process of constructing facts, Lewontin maintains, must be historicized; recognizing the contingency of these ongoing processes means that in physical sciences such as "biology there may be *general* statements, but there are no universals, and . . . actual events are the nexus of multiple causal pathways and chance perturbations" (147). By complicating notions of causality, Lewontin renders the practice of science both inductive and historicist because "experimental [and] observational protocols" must themselves be flexible and dynamic in order to describe accurately a dynamic physical reality.

Lewontin's comments indicate something of the resistance among scientists to universalizing assumptions and deterministic metaphors. As George Lakoff and Mark Johnson suggest in their study of metaphor, "truth is relative to our conceptual system, which is grounded in and constantly tested by, our experience with our cultural and physical environments" (1980, 193); consequently, scientific language is always troubled and enriched by the interference patterns of differing discourses (Bono 1990, 59–90; see also Woolgar 1988; Rotman 1993). This attention to the relationship between physical reality and systems of representation allows both scientists and cultural critics to offer complex and self-critical descriptions of the systems of signification and knowledge making that they, and others, employ. Rather than opposing objective truth to subjective belief, Lewontin insists that scientific systems of representation are historically and culturally mediated, and he advocates extending a methodological rigor and skepticism to analyzing their specialized languages and modes of representation rather than simply assuming that they are value-neutral reflections of a transhistorical reality. Neither scientists such as Lewontin nor cultural critics of science such as Shapin make the obviously absurd claim that the world is a hodgepodge of subjective impositions. Instead they maintain that because all systems of representation are contingent there can be no unmediated access to "reality."

Rather than providing easy paths to consensus, scientific debates grow heated and end in disputes about data, methodology, and even competence because different groups of scientists have different institutional and disciplinary investments, a point that I will develop at length in this study. Admittedly, it would be easier to believe, in the words of physicist Steven Weinberg, that truth and representation are reflexive, that "the correct [scientific] answer when we find it is what it is because that is the way the world is" (1996, 14). But this view offers no means to assess the plausibility of claims when scientists, red-faced with rage or otherwise, arrive at different interpretations of phenomena. The differences between Weinberg's language—based on four iterations of an intransitive verb—and Hartmann's language are striking, even though both men are describing ostensibly the same process: how scientists arrive at the "truth." Hartmann describes a historical situation in which the quality of the "best data" depends on all sorts of outside factors, ranging from the reliability of subcontractors, to political debates over scientific funding, to the assumptions behind the instruments being flown into space. Weinberg, in contrast, deals in epistemological absolutes. The limitations of such a reflection theory of scientific representation become evident when its proponents try to account for conflicts within science—such as those endemic to debates about Mars in the nineteenth, twentieth, and twenty-first centuries.

The study of the red planet since 1878 has produced a series of paradigm-shattering discoveries that time and again have rendered previously accepted wisdom about the planet spectacularly wrong. What makes this history so fascinating is that almost all efforts to form legitimate inferences about Mars from limited, disputed, and ambiguous data have been hotly contested. As generations of astronomers have studied the planet, new technologies have been developed, new data collected, and new interpretations offered that have allowed planetary scientists to arrive, at different points in time, at different versions of the "best estimate" of the truth about Mars.

Debates about life on Mars, from canal-building Martians to suspected nanofossils, reveal the ways in which scientific discussions are embedded in complex professional networks and in ideology—the assumptions, values, and beliefs that are taken for granted, half articulated, or defended vigorously as the self-evident parameters of good judgment and common sense. Ideology is not primarily a consciously held set of beliefs or a "false consciousness" that is diametrically opposed to the objective realities of science; instead it describes the culturally and technologically specific ways in which knowledge is put together and disseminated. Ideology is the cultural form of complex dynamics; and its negotiations of "knowledge" and "meaning" both redefine and constrain our horizons of expectation and intelligibility. In this regard, the cultural study of science does not maintain that "society," "ideology," or "politics" determine scientific practices or knowledge but demonstrates why the discourses and practices of science cannot be hermetically sealed from their sociocultural environments. Put simply, there is no way to separate "society" or "culture" from "science" and "technology," no standpoint from outside the cultural matrix from which one could make such distinctions. Therefore, while the practice of a particular science never can be reduced to a "nonscientific" belief system, it also can never exist independently of the systems of representation, belief, legitimation, and socioeconomic rewards that make possible its complex practices of knowledge making. This is the distinction that Shapin makes between "the [social and professional] bases of scientific authority and epistemological absolutism" (1999, 13). No one would argue against the proposition that the scientific study of Mars is cumulative and progressive: technological developments in telescopes and then in spacecraft design, photography, spectroscopy, and computer hardware and software have allowed scientists increasingly to collect more, and more accurate, data and to pose far more precise questions than their predecessors did in 1903, 1933, or 1963. At the same time, however, this history is embedded in larger scientific and nonscientific discourses and practices—in the complex processes of contextualization that I describe below.

MARS, EVOLUTION, AND THE ECOLOGICAL IMAGINATION

The analogies between Mars and Earth proposed in the nineteenth century depended in large measure on visual inference: the waxing and waning of the polar caps and the wave of darkening that swept across the planet suggested to almost all astronomers an earthlike ecology, even those who believed that Mars harbored only low forms of vegetation and animal life. For some scientists, as well as for many who followed the controversies in the popular press, the effects of environmental change on Mars's presumed inhabitants became a topic of intense speculation. The canal theory owed much of its appeal to the analogies it suggested to ecological concerns on Earth. Severe droughts in the late nineteenth century ravaged large areas in India, Africa, China, and Brazil, and the environmental writing of the period often dealt as much with problems of resource management, labor, agriculture, and pollution as it did with the beauties of a pristine nature (Davis 2001; O'Connor 1998; Bramwell 1989; Worster 1993, 1994). Mars became a prominent object of speculation because its presumed inhabitants, digging canals thousands of miles long to connect various "oases," seemingly provided an object lesson in harnessing political will and technological expertise in the service of a larger social good—staving off environmental collapse by husbanding dwindling supplies of water.

To conceive of ecological change on Earth occurring on a planetary scale, nineteenth- and twentieth-century observers resorted to imagining intelligent creatures on Mars looking at our planet. Visualizing how the Earth might appear from space involved a number of uncertain assumptions and best-guess analogies, many of them back formations based on what astronomers could observe on Mars. With its seasonal changes, the fourth planet provided a refracted image of what the Earth might look like from space, and both popular and scientific discussions of Mars between 1880 and 1964 therefore reveal some of the problems that attended efforts to understand our planet as an integrated set of biological, hydrological, and climatological systems. The Earth, seen from the eyes of putative Martians, became a site to speculate about the consequences of humankind's exploitation of its resources and the fragility of its biosphere. The understanding of the complex feedback loops between organism and environment that developed during the twentieth century stems, in part, from the ways in which Mars encouraged scientists to think about the planetwide conditions necessary to sustain life.

It is significant that Mars became an object lesson in planetary ecology at the same time that the discourses of physics and neoclassical economics seized on the concept of the conservation of energy as a way to understand the seemingly ironclad "laws" of the natural and socioeconomic world. Both domains employed what Philip Mirowski terms "a reciprocal metaphorical legitimation" in order to justify research programs that ultimately depended on "an ideal of unification" (1989, 108) of disparate phenomena. This ideal, in turn, was predicated on "a purely abstract, conventional standard"(115)—a belief in the epistemological absolutism of its representational schemes that defined the physical (and economic) universe by time-independent laws. As Mirowski demonstrates, the concept of the conservation of energy, based on a mathematical formalism, did not describe the natural world so much as it asserted "the very ideal of natural law: the mathematical expression of invariance through time, the verification of a stable external world independent of our activity or inquiry" (75). Mirowski's analysis is useful in explaining why nineteenth-century discussions of ecology paradoxically commit themselves to two different, even incommensurate, views of the relationship between the natural world and humans. The first is an economics of indefinite growth that identifies progress with an ad hoc principle of invariance; this view assumes that technological innovation and industrial expansion continually can develop new resources to replace those being depleted. The second view envisions the world as a set of closed systems, an ecology defined by limits and carrying capacities that can be temporarily extended only at the expense of sustainability (Ashworth 1995, 124–34). Paradoxically, the dominant metaphor for describing both worldviews was derived from the second law of thermodynamics; entropy could be appropriated to predict a downward spiral, over eons, of the physical universe and therefore the Earth itself: humankind could respond either by circumventing or transcending environmental limits or succumbing to resource exhaustion, scarcity, and social disintegration (Clarke 2001; Gold 2002, 449–64). Not surprisingly, Mars was invoked to buttress both of these views.

The idea that the universe was in the thrall of evolutionary laws that determined the life cycles of the planets was generally accepted throughout the nineteenth century and into the early twentieth (Brush 1987, 245–78). For some scientists, notably Lowell, the prospect of Mars as a dying world challenged theological notions of "man's" place in the cosmos by mocking humankind's pretensions to transcend ostensibly universal laws of planetary evolution and their inevitable consequences—the entropic heat death of all planets that would lead to drought, scarcity, privation, and ultimately extinction. In this respect, a roughrider optimism about economic growth as a means to overcome ecological limits constituted only one half of a dialectic; the alternative held that not only individual species but entire worlds were destined to suffer the eventual loss of water, heat, and atmosphere. Therefore the notion that intelligent beings on Mars were grimly crisscrossing their world with canals seemed, to some, both a harbinger of humankind's fate and a universal Darwinian response of intelligence to the problems posed by planetary desiccation.

In some striking ways, bringing Mars within the orbit of "environmentalist" principles anticipated one of the fundamental principles of current ecological thinking: the idea that landscapes manifest "ongoing dialectical relations between human acts and acts of nature" (Crumley 1994, 9). Rather than reinforcing romantic notions of living in "harmony" with nature, Mars figured into scientific discourses that conceived of these "dialectical relations" in terms of the costs and consequences of *intensification.* Intensification is defined by the cultural anthropologist Marvin Harris as "the investment of more soil, water, minerals, or energy per unit of time or area." While such escalating investments are humankind's "recurrent response to threats against living standards," intensification invariably proves counterproductive over time because "the increased effort sooner or later must be applied to more remote, less reliable, and less bountiful animals, plants, soils, minerals, and sources of energy" (1976, 5). As resources become increasingly scarce, living standards decline, usually with disastrous consequences for the most vulnerable populations, until cultures "invent new and more efficient means of production which sooner or later again lead to the depletion of the natural environment" (5). Such a view of intensification underscores the complex interactions among climactic variations, population pressures, technological developments, rates of resource extraction, environmental degradation, the need to maintain living standards, food production, working conditions, political power, transportation requirements, economic structures, and social customs (Markley 1999b, 817–37).

During the years of the canal controversy, as I argue in chapter 2, the consequences of intensification were cast in the ontogenetic analogies that dominated nineteenth-century biology.[5] In turn, these analogies encouraged cosmological narratives, such as theories of planetary life cycles, based on the universalizing concepts that Mirowski describes. As ecology and physical sciences underwent profound changes throughout the twentieth century, so too did the inflections of the analogies between Mars and Earth. The Mars that has emerged since 1965 has been informed by conceptual and methodological changes within the disciplines of ecology and microbiology. Historical ecologists such as Elizabeth Graham thus describe the study of Earth in language that has affinities with both the discourses of planetology and the language and methodology of the cultural studies of science. These affinities might be described as a shared epistemological heuristic, one that challenges the supposedly fundamental distinctions that are said to exist between the sciences and the humanities (Haraway 1991; Bryld and Lykke 1999; Plotnitsky 2002; Brande 2006). Rather than emphasizing stability in ecosystems and holistic and deterministic notions of "system," many ecologists base their analyses on models of heterarchy, which according to Graham is "a system in which elements are unranked . . . or ranked in a variety of ways depending on conditions," or "scalar hierarchies" in which any level of organization can affect or temporarily control others (1998, 124). On Earth, at least, such heterarchies imply scientific methodologies that work "by embodying contradiction" and therefore "allow [scientists] to move more freely among the three realms [of nature, society, and meaning] because [historical ecology] does not require a macrotheory to integrate them" (125). Mars, as yet, lacks an indigenous social science, but the complex, nondeterministic methodology that Graham describes foregrounds an attention to complex interactions among science, meaning, and culture rather than an unwavering belief in determinant causes and predictable effects.

The analogies I have suggested among the methodological languages of ecology, areology, and the cultural study of science cannot disguise the fact that scientists and cultural critics typically hold very different notions of causation: the "best" explanations for scientists are the simplest; the "best" interpretations for cultural and literary critics are those that register the complexity that evades macrotheories. Yet simplicity itself, as I argue throughout this study, is always a contested term within science. In different contexts simplicity can be, and has been, invoked to defend mutually exclusive hypotheses about life on Mars. Scientists on both sides of the canal debate, the interpretation of the Viking life detection experiments, and the current controversy over nanofossils in ALH84001 invoke classical ideals of parsimony—Occam's razor: the idea that the simpler the explanation the better—as their trump card to justify their interpretations of available data. Yet such appeals to simplicity invoke aesthetic standards of epistemological elegance. In turn, these standards involve larger conceptions of order—aesthetic, philosophical, and theological as well as "purely" scientific. While communities of scientists and artists may share broadly acknowledged aesthetic standards, these standards are themselves historically contingent, embedded in complex cultural assumptions, practices, and values. Consequently, they remain open to competing interpretations (Gauch 1993, 468–78). Employing Occam's razor, in short, requires unpacking a whole shaving kit. Consequently, although one of the interpretations of the carbonate structures in the Martian meteorite, at some point in the future, will be proved "right," all of the interpretations of these structures—right and wrong—are shaped by cultural, historical, and disciplinary assumptions, by different ways of deploying the languages of epistemological simplicity.

SCIENCE AND SCIENCE FICTION: THE LURE OF THE RED PLANET

With the release of the presidential commission's June 2004 report recommending eventual human voyages to the Moon and Mars, debates about the future of planetary exploration are raging on the Internet, in the popular press, and among scientists. The commission's recommendations, like all such scenarios, depend on projecting into the future a sequence of events and likely outcomes that can be simulated but never predicted with any certainty. The further into the future that scientists project scenarios for harvesting solar energy and minerals from asteroids, the Moon, and Mars, the more imaginative such speculation becomes (Lewis 1996; Schmidt and Zubrin 1996; O'Neill 2000). At the boundaries between extrapolations from existing data and speculations that project contemporary cultural, political, and economic assumptions into the future lies the realm of science fiction. What Carl Sagan terms "the continuing dance between science and science fiction" (1994, 340) involves the kinds of complex interactions between physical reality and modes of imaginative expression that, in different ways, Lewontin and Graham describe. Science fiction, however, does not extrapolate from given facts so much as it simulates possible or alternative realities. For cultural critics, investigating the affiliations between science and science fiction does not mean simply passing aesthetic judgments on particular texts but investigating the reasons why some works, like Burroughs's novels, prove extraordinarily popular and influential, even when they are panned by literary critics.

To study the significance of Mars as a dying planet in popular culture is to explore the political implications of science fiction. Most practitioners and critics of the genre take pains to distinguish its aims and methods from those of canonical literature. As "an unconscious and figurative projection of some more 'realistic' account of our situation" (Jameson 1989, 283), science fiction does not reflect a familiar reality but suggests ways in which alternative realities or future histories might take shape given other initial or governing conditions. Rather than representing what is or has been, science fiction offers a simulation of what might be; it changes the postulates of realistic fiction and then runs simulations based on these premises. In contrast to postmodern conceptions of representation predicated on lack (the absence of the signified) or deferral (the gap between the signifier and the signified), simulation, Steve Shaviro argues, "precedes its object: it doesn't imitate or stand in for a given thing, but provides a program for generating it. The simulacrum is the birth of the thing, rather than its death" (1996, 17). In Shaviro's sense, science fiction works by convincing its readers of the internal consistency of its simulation so that its obvious differences from reality engender both "cognition," the recognition that an imagined world can be compared to the reader's experience of her or his reality, and "estrangement," the recognition that its differences from "reality" provide a means to analyze the ideological conditions of existence that the reader otherwise takes for granted (Suvin 1979, 7–9). That said, anyone who has read a lot science fiction realizes that much of it is pretty bad. Most science fiction novels do not explore the complex interactions between cognition and estrangement but reduce simulation to caricature, imagining that while technologies will change, human (or inhuman) nature never evolves beyond hoary stereotypes. Some simulations, in this regard, are more convincing and thought provoking than others precisely because they ask to be judged both by the standards of aesthetic consistency and by their ability to challenge, question, or defamiliarize the historical experience of their readers.

If estrangement marks the difference of these imagined worlds from historical reality, as Fredric Jameson and Darko Suvin argue, these differences allow readers to imagine that their socioeconomic and political reality could be otherwise: the "homemade qualities and amateurishness" of much science fiction, Jameson contends, are not marks of their aesthetic limitations but indicate "their political function . . . *to bring the reader up short against the atrophy of the utopian imagination and of the political vision in our own society*" (1987, 54). This political function of science fiction offers a means to "dramatize this contradiction" between history as an open-ended process and the formal constraints of narrative closure; therefore, Jameson argues, because "the vision of future history" can neither know nor predict the future, history itself becomes a "work in progress," defined by its potential rather than by its representation of current social, economic, and political conditions (Jameson 1982, 148; see also Philmus 1970; Penley 1997). Science fiction registers possibilities; it does not make predictions. If, as Suvin suggests, the genre exists "between the utopian and anti-utopian horizons" (1979, 62), it is because science fiction resists formal—and ideological—closure.

Suvin's and Jameson's definitions suggest why science fiction seems to oscillate between ideological critique and escapist fantasy. The relationship between "reality" and the logic of simulation is paradoxical because the two realms are both opposed and mutually constitutive. "Realistic" projections for, say, the future explorations of Mars—the idea, for example, that the planet can provide abundant resources to sustain and expand human civilization (Lewis 1996; Schmidt and Zubrin 1996)—depends explicitly and implicitly on the traditions of science fiction to provide a narrative mapping for an uncharted conceptual space; conversely, science-fiction authors frequently defend the genre's literary and social value by emphasizing the significance of its "realistic" extrapolations from current science and technology. The novelist and anthologist Judith Merril, several decades ago, claimed that " 'realistic fiction,' rather than speculative or science fiction, was the transient oddity—[a] grotesque . . . product of nineteenth-century super-rationalism and mechanistic philosophy" (1971, 61). In defending science fiction, she argues that literary realism narcissistically inflates individualistic concerns to the status of "universal" human problems, thereby ignoring or marginalizing the profound effects on human and social identity of scientific and technological innovation. For this reason, Merril maintains that "the literature of the mid twentieth century can be meaningful only in so far as it perceives, and relates to, the central reality of our culture: the revolution in scientific thought which has replaced mechanics with dynamics, classification with integration, positivism with relativity, certainties with statistical probabilities, dualism with parity" (54). Although she describes these transitions in oppositional terms, she also insists that science fiction foregrounds irrevocably complex relationships between science and society. During the 1940s and 1950s, she argues, science fiction helped to raise "the acceptance threshold of society in general and of the scientific/technical segment in particular" for the paradigm shifts she describes. As Constance Penley (1997) suggests, it is the fantasy at the heart of "realism" and the "realism" at the heart of fantasy that explains our fascination with the genre.

Merril's comments anticipate, in some respects, both the theoretical concerns of cultural critics of science, such as Latour and Haraway, and later analyses by science-fiction writers who distinguish their genre from the aesthetic, social, and political values of realistic fiction. Samuel Delany shares Suvin, Jameson, and Merril's conviction that the genre's willful distortions of "reality" offer possibilities for a social criticism that rejects "the monologic aesthetic" of modernism "in which art itself denies all dialogue, contest, agonism, and history to become an individual subject's representation *of* an individual subject (or a series of individual subjects) *for* an individual subject, with the exciting, material, impinging social object relegated to a wholly secondary position" (1994, 192, 194). By inverting, complicating, or disrupting the conventional relationship between subject and object, the "genre-effect" of science fiction blurs distinctions between "high" and "popular" art (194). Rather than placing humankind at the center of a coherent representational narrative, science fiction allows other kinds of "subjects"—cyborgs, software programs, and aliens—to speak for themselves. The imagined technologies and strange environments of science fiction become ways to simulate in provocative ways the dialogic relationship that exists between interpenetrating "subjects" and "objects" in historical reality.

Delany's "exciting, material, impinging social object" has affinities with Latour's "actant" (1987), his designator for material objects—flesh, blood, silicon, plastic, steel, copper, or wood—that cut across and blur distinctions between mind and matter, subject and object, and nature and culture. According to Latour and Delany, the laptop on which I am writing this sentence is not a passive object or a reification of design specifications, human expertise, production techniques, semiskilled labor, and operating and word processing systems that "I" use; rather it redefines what I, a human subject, can do and think, radically altering my techniques of composition and my understanding of my relationship to print and electronic media (Markley 1996, 55–77). Technologies and identity are mutually constitutive: things "use" humans, Latour argues, as much as humans use them. Science studies and science fiction share this fascination with reconceiving the relationship between humankind and technology and, more broadly, between humankind and a complex material reality—including the twentieth century's favorite site for interplanetary science fiction, Mars.

For a planet that no human has visited, Mars plays a surprisingly significant role in defining the intersections between individual and sociocultural identities and the physical universe. Since H. G. Wells published *War of the Worlds* in 1898, Mars has imposed the ecological constraints of a dying planet on the imaginations of writers and readers. Science fiction about Mars is obsessed with ecological issues, insistently foregrounding the problems of survival for humans and Martians in a fragile or exhausted environment. The notion of a dying planet paradoxically spurs the cultural imagination precisely because it imposes severe environmental constraints on human explorers or Martian civilizations. Consequently, as Mars becomes a favored site to depict the consequences of resource exhaustion—battles against rivals and against a hostile or indifferent nature—the planet offers refracted visions of political economy on Earth. Lowellian Mars served as a crucial impetus in the early twentieth century for scientists, novelists, and social commentators to view Earth itself not as a patchwork of countries, tribes, and localities, or a boundless reserve to be exploited for adventure and profit, but as a global ecosystem in crisis.

Paul Alkon credits science fiction with "offer[ing] our most powerful literary defense against unthinking collaboration with the impulses behind our worst nightmares" (1987, 4), and quite often Mars is the setting for ecological versions of these nightmares of planetwide exploitation. In projecting evolutionary narratives onto the natural history of the solar system, science-fiction writers followed Lowell in seeing Mars as an older and more decrepit version of Earth. In his study of twentieth-century pulp fiction, Paul Carter suggests that "Mars as a nineteenth-century frontier America and Venus as a nineteenth-century frontier Africa had a mythic appeal that pushed aside all demands of scientific exactitude" (1977, 65), but the two planets served different functions and generated different kinds of narratives. Cloud-shrouded Venus may have given writers free rein to fantasize about jungle beasts and warring tribes, but its featureless disk imposed no ecological constraints on the imagination and suggested no tragic narrative foreshadowing the fate of the Earth. In contrast, Mars determined a course of sociocultural as well as planetary history: the response of an advanced civilization to a dying world. Venus was the abode of primitive life-forms or the kinds of the "backward" humanoids who Europeans and Americans already had subjected and colonized. In contrast, even "primitive" Martians (those imagined by Leigh Brackett and Philip K. Dick, for example) had degenerated from a master race of canal builders. In describing ecological devastation on a planetary scale, science fiction about Mars offers a refracted image of humankind's efforts to live on an Earth disfigured by industrialization, pollution, and resource depletion.

The persistence of this image of a dying planet in science fiction reveals something of the dark underside of modern myths of technological and social progress. Dying, after all, is a liminal state; it is both a process and a border between human experience and the absolute, whether that absolute is figured as spiritual transcendence or utter annihilation. Dying also implies a transition through time and history, and the use of this metaphor to describe planetary life cycles projects onto Mars explicit values and implicit assumptions about the passing of civilization. The planet offered readers the vicarious experience of inhabiting an always liminal world. In popular culture, Mars is both a ghost planet haunted by past life-forms—from the vanished civilizations of twentieth-century pulp fiction to the putative nanofossils of exobiological controversy—and a world waiting to be inhabited, or already haunted by, future generations of human explorers and colonists. At the end of Ray Bradbury's *Martian Chronicles,* the last family of colonists on Mars see their reflections in a canal. The Martians have died off, although they move spectrally throughout the vignettes that comprise the novel; humankind has destroyed itself in a nuclear holocaust. When one of the children asks his father where the Martians are, the man points to their reflections in the water: "The Martians stared back up at them for a long, long silent time from the rippling water" (1950, 181). Metaphorically, the imagined colonists of the future are identified with the ghosts of a long vanished past, and, for Bradbury and many others, Mars remains a planet haunted by both its past and its future.

The spectres of a once-living world that haunt a now-dead or dying planet recur frequently in science fiction because they represent the paradoxes of temporal dislocation: a past and future that alike disturb the present. The languages of popular culture and planetology are full of the ghosts of Mars, ghosts who seem uncanny harbingers of the fate of the

Earth. Planetary scientists such as John Lewis often deploy such images to describe the loss, over eons, of the planet's water and atmosphere: "Mars today," he writes, "is but a ghost of the planet it once was" (1996, 150). The line between science and fiction in such comments blurs because our understanding of the surface of Mars is haunted by evidence of a dynamic, if not a biological, past. As Lowell's canal builders receded from science fiction, they were replaced by the new ghosts of long-vanished aliens who have left behind ancient cliff dwellings (Ben Bova's *Return to Mars* [1999]), mysterious artifacts (William K. Hartmann's *Mars Underground* [1997]), and the so-called face on Mars, the mile-long plateau supposedly carved to resemble a humanoid face by a mysterious civilization (Allen Steele's *Labyrinth of Night* [1992]; Ian Douglas's *Semper Mars* [1998]). In the best of these novels, such as Hartmann's or Terry Bisson's *Voyage to the Red Planet* (1990), no ultimate or originary truth underlies or explains the uncanny artifacts left by billion-year-old civilizations. They are, in one sense, ghostly markers for a virtual future of human exploration and colonization. Like Bradbury's Martians, the alien artifacts of 1990s science fiction bring disparate, even contradictory, views of the planet into the same fictional space. In turn, this fictional future of human settlements and terraforming technologies serves as the ultimate goal for enthusiasts in the Mars Society, for the authors of the 2004 presidential commission report on the United States space program, and for a number of well-respected scientists.

In this study, the chapters on science and those on science fiction alternate and interweave. My purpose (as this Introduction suggests) is not to divide "science" from "fiction" but to pursue the internal logic of developments in each genre as well as to explore the ways in which their concerns overlap and interpenetrate. The chapters that follow, then, do not indicate hard and fast conceptual boundaries but explore the territories that science and science fiction share.

Chapter 1 traces debates about Mars and its imagined inhabitants from the seventeenth through the late nineteenth century. After Kepler and Galileo, belief in the plurality of worlds played an important role in seventeenth-century intellectual history; in addition to the well-known works of Bernard le Bovier de Fontenelle and Christiaan Huygens, debates about life on other planets intrigued some of the major literary figures of the period, notably Aphra Behn (Fontenelle's translator) and Daniel Defoe. As telescopes improved in the eighteenth and nineteenth centuries, Mars became increasingly important in debates about extraterrestrial intelligence, particularly in the work of William Herschel, who placed Mars at the center of exobiological speculation. By the time Camille Flammarion produced his massive history of the planet in 1892, a consensus had emerged that was based on analogies between Mars's seasonal changes and terrestrial climatology. In turn, however, such analogies also reshaped conceptions of Earth. The major challenge to visions of an earthlike Mars came from Giovanni Schiaparelli, who saw and drew a complex network of straight lines, *canali,* on its surface. These canali touched off a half century of debate: some observers denied their existence, others confirmed Schiaparelli's observations and argued that they were natural geological features; and still others, including Flammarion, entertained the idea that they were the artificial products of intelligent Martians. Schiaparelli remained reticent to explain the significance of his canali, and his own commentaries focus on the scientific and philosophical problems of analogical reasoning.

The second chapter examines Lowell's canal theory in the contexts of nineteenth- and early-twentieth-century scientific, environmental, social, and political thought. A master stylist and popularizer, Lowell offered a plausible narrative that drew effectively on two major scientific theories of the period: the nebular hypothesis of planetary formation and Darwinian evolution. For many readers, he provided eloquent defenses of scientific progress and secular objectivity by decentering humankind in the universe. In contrast, his major critics—among them E. W. Maunder and Alfred Russel Wallace—argued from theological as well as scientific postulates that "man" was alone in the universe. These critics, however, were often divided among themselves, some accepting his maps of the canals, others claiming that the straight lines he mapped were illusory. Yet even many of these skeptics accepted key aspects of Lowell's thesis—that cold and dry Mars offered a harbinger of Earth's future. In this respect, Lowell's view of Mars as a dying world both drew on contemporary ecological concerns—particularly the loss of arable land in equatorial deserts—and encouraged his readers to imagine a technologically advanced civilization confronting dire environmental conditions. For all his political and social conservatism, Lowell's grim narrative of the evolution of worlds from life-bearing planets to desiccated husks challenged metanarratives of technological progress and manifest destiny. While E. E. Barnard, Maunder, and Wallace offered trenchant critiques of the canal thesis, Lowell and his allies launched vigorous counterattacks. Beginning in 1905, the photographs of Mars by Lowell's assistant, V. M.

Slipher, in the eyes of most observers, confirmed the general character of the planet's surface that Lowell described. The canals of Mars attracted serious attention from literary figures, scientists, philosophers, and political theorists as a site of speculation about the interactions among a hostile environment, evolutionary pressures, and the sociopolitical organization of intelligent beings forced to cope with an ecological catastrophe.

Chapter 3 deals with the outpouring of science fiction about Mars written between 1880 and 1910. Before Lowell, Mars was a popular setting for utopias that offered different visions of the technoscientific and sociopolitical ideals of advanced civilizations. After 1895, however, science fiction became concerned with depicting the social, political, and economic consequences on Lowell's dying planet. Although H. G. Wells's *War of the Worlds* is the best known of the turn-of-the-century science-fiction novels, works by Kurd Lasswitz, Alexander Bogdanov, and Alexei Tolstoy offered popular, often compelling visions of the significance of advanced Martian civilizations. Wells's alien invaders allow the novelist to critique nineteenth-century imperialism and human pretensions to scientific mastery and metaphysical significance. In depicting humanoid Martians, Lasswitz and Bogdanov extend popular analogies between the two planets to challenge the values and assumptions of European civilization. What unites these three novelists is the belief that ecology is destiny—that the fate of intelligent Martians is tied irrevocably to the evolutionary decline of their planet.

Chapter 4 explores the afterlife of Lowell's canal thesis in midcentury planetology. Between Lowell's death in 1916 and the Mariner 4 mission in 1965, most scientists accepted some aspects of Lowellian Mars—a dry, cold world still characterized by some form of vegetation—while dismissing his canal-building Martians. Yet temperature measurements by William Coblentz in the 1920s led to a brief revival of the canal theory; simmering controversies about the canals hinged on the varying interpretations of results from thermocouples, new spectrographic techniques, photographs, and, after World War II, radio astronomy. In charting the ups and downs of the canal thesis through the 1930s, I examine a 1928 *New York Times* article that surveyed twelve prominent American astronomers and found them divided in their beliefs about the canals. Even Lowell's critics conceded the existence of some kind of linear markings on the surface and acknowledged the possibility that Lowell may have been right. Such interpretations, as Henry Norris Russell concluded, did not constitute proof, and he and several other astronomers withheld judgment. By 1933, however, the canals had begun to fade when researchers failed to detect water vapor in the planet's atmosphere. Nonetheless, studies of Mars for the next thirty years struggled to reconcile the seeming existence of vegetation with evidence that the planet was so cold and dry that it could not support terrestrial life.

Chapter 5 discusses the half century of Martian science fiction between Lowell's death and the first Mariner missions to Mars. Beginning before World War I, Edgar Rice Burroughs crafted a series of ten Martian novels that proved enormously influential. Burroughs invented the first mass-media American superhero, John Carter, while exploiting and popularizing the vision of a dying world. In depicting this Earthman's adventures among various human and nonhuman races struggling to survive on Mars, Burroughs defined the action-adventure genre in terms that both draw on and challenge myths of the American frontier. Burroughs's followers in the 1930s through the 1950s adapted these conventions to dramatize the ecological trade-offs that characterize existence on a dying planet. In studying novels and stories by P. Schuyler Miller, C. S. Lewis, Leigh Brackett, C. M. Kornbluth and Judith Merril, Lester del Ray, and Ray Bradbury; Howard Koch's 1938 radio adaptation of *The War of the Worlds* for the Mercury Theatre; and two 1950s science-fiction films, I explore the dialectically related logics of cynicism and paranoia that shape the ideational landscape of midcentury science fiction. Mars becomes both a site for serious political protest against no-holds-barred capitalism and a camp setting for matinee redactions of Wells's invaders. It allows writers and readers to deal with the paradox of imagined colonization: liberal-utopian ideals of cooperation fostered by the need to manage scare resources set against the industrial and corporatist models of planetary exploitation. For Bradbury, Brackett, and others, Mars became a vehicle to critique the self-destructive militarism and mindless conformity of postwar America.

Chapter 6 examines the Mariner and Viking missions between 1964 and 1976 that substantially altered scientific views of Mars. The photographs taken by Mariners 4, 6, and 7 revealed a cratered, lunarlike surface that ended speculation about canals and stretched the limits of longstanding analogies to Earth. But in 1972 Mariner 9 returned over seven thousand photographs of the planet that revealed massive shield volcanoes, a canyon system three thousand miles long, and evidence that water had once flowed across the surface. This mission literally remapped the surface of the planet and raised a host of questions about its chemical composition and geomorphic history. In 1976, the Viking missions placed the first two landers to function successfully on Mars. While the

Viking orbiters photographed the planet's surface and studied its atmosphere and geology, the landers conducted three experiments to search for microbial life. The results, at first ambiguous, eventually were interpreted by most scientists as evidence of a lifeless, arid world bathed in ultraviolet radiation. The life-detection experiments and the orbital photographs marked important advances in interplanetary exploration, but their results also provoked new debates about the usefulness of continuing the search for life on Mars.

Chapter 7 examines the response of science-fiction authors, movie directors, and readers to the red and apparently dead Mars of the post-Mariner era. In the pre-1964 novels and short fiction of Robert Heinlein and Philip K. Dick, Mars retained some of its associations with ancient races and the commercial exploitation of a new frontier; after Mariner 4, it became the site for pointed critiques of the myths of new frontiers and new beginnings. In the late 1960s and early 1970s, British and European writers, such as D. G. Compton and Ludwig Pesek, painted bleak pictures of humankind's future on the planet. After the Viking missions, American authors, including scientists such as Hartmann, Gregory Benford, and Robert Zubrin—depicted fictional voyages to Mars that extrapolated from existing knowledge to speculate about what astronauts eventually may find. Even before the missions of the 1960s, however, other science-fiction writers, including Arthur C. Clarke, Isaac Asimov, and Walter M. Miller, speculated about terraforming the planet to make it habitable for human colonists. To conclude this chapter, I discuss Paul Verhoeven's *Total Recall,* a significant film in both popularizing the idea of terraforming and shaping that myth as a conservative fantasy of a new frontier safe for capitalist exploitation.

Chapter 8 traces changing perceptions of Mars since the Viking missions. Even as planetologists proposed various theories about the planet's geological past, controversies over the possibility of fossilized nanobacteria have provoked debates about what constitutes probable evidence of past or current life on Mars. In both geology and biology, seemingly anomalous data has led to reassessments of the methods and assumptions governing areology. In tracing ongoing debates about Mars and Martian meteorites, I explore the ways in which evidence of geologically recent water erosion, the detection of large amounts of subsurface water, and the success of the 2004 rover missions have affected planning for future missions. Mars remains a catalyst for the development of both innovative technologies in planetary exploration and new theories within comparative planetology. It is also a site for scientists, historians, philosophers, and cultural critics of science to explore the ways in which anomalous data redefine dynamically contemporary technoscience.

Chapter 9 examines Kim Stanley Robinson's trilogy, *Red Mars* (1993), *Green Mars* (1994), and *Blue Mars* (1996), the most influential Mars novels since Bradbury's *Martian Chronicles.* Drawing on scientific speculation about the possibility of terraforming, Robinson rethinks conceptions of planetary ecology, the interlocking systems that create and sustain the conditions that allow life to flourish, and political economy, the distribution of scarce resources among competing populations and interests. Beginning with two short stories, "Exploring Fossil Canyon" (1982) and "Green Mars" (1985), and continuing in the trilogy and his collection of stories, sketches, and poems, *The Martians* (1999), Robinson explores the utopian possibilities of depicting alternatives to the ideological conflicts and economic and ecological crises of the late twentieth century. In dealing with the fictional possibilities of terraforming Mars, the novelist suggests that the antagonism of environment and exploitation can be subsumed in what his characters call "eco-economics," a means of calculating value in order to minimize the degradation of the planet and to ensure social justice. In this regard, Robinson's Mars novels call into question the exploitative logic of late-twentieth-century capitalism to suggest alternatives to ever-increasing cycles of intensification and environmental degradation. *Red Mars, Green Mars,* and *Blue Mars* draw on and reconfigure the utopian tradition of science fiction represented by Lasswitz and Bogdanov.

CODA: AGNOSTICISM

At a prelaunch press conference in 1975, seventeen Viking scientists "were asked for a show of hands on whether they believed there was life on Mars. At first no hands went up; then 2 or 3 were raised; and after about a minute there were 11" (Cooper 1980, 12). The scientists' reticence to commit to a belief in even microscopic Martians harks back to the agnosticism of Schiaparelli and Behn and suggests as well the lure of a science-fiction tradition that still imagines Mars as the abode of strange life. In the mid-seventies, the differences among Viking researchers extended to questions about the usefulness of trying to detect alien life and to the philosophical and methodological differences among the three teams that conducted the Viking biology experiments. More generally, the scientists' delayed reaction is a representative moment in the history of our understanding: the eight or nine hands that hesitantly went up testify both to the problems of searching for exotic life-forms and to the agnosticism about exobiology that recurs throughout the scientific literature. The difficulty that Mars presents in 2005 is not so much imagining a single life-form that might eke out an existence on or under its surface, but in imagining the complex environmental systems—water, energy sources, transportation, reproduction, protection against ultraviolet radiation, and reciprocal effects on the environment—that would have to exist as well. If and when sixteen future scientists are ready to touch down on Mars and begin examining the most promising sites where life may have existed, a similar "show of hands" is likely still to produce a similar reaction: hesitant, hopeful, and agnostic.