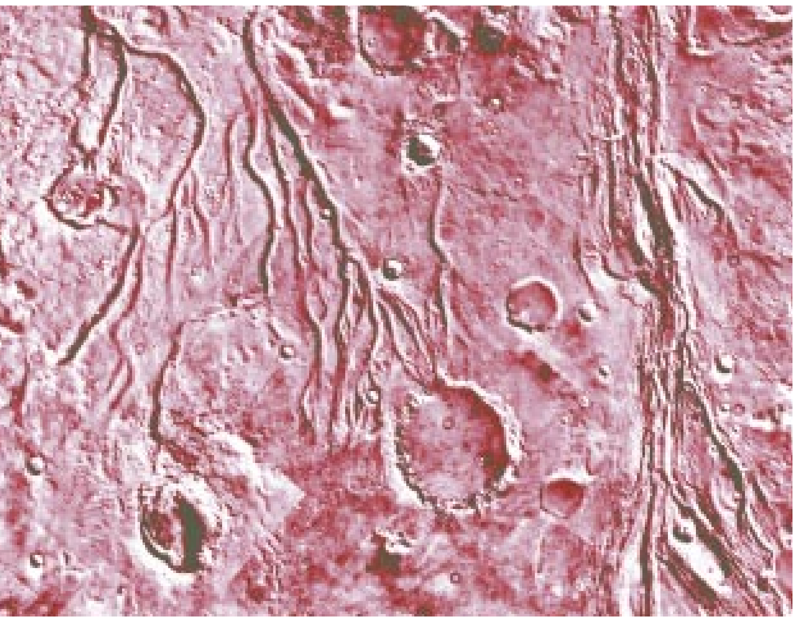
the allure of the red planet

Mars—the Red Planet, the Bringer of War—has inspired over the centuries wild flights of imagination, and at the same time intense scientific interest. A source of hostile invaders of Earth, the home of dying civilizations, a rough-and-tumble mining colony of the future—all are in the realm of science fiction, but they are based on seeds planted by centuries of scientific observation. Mars has shown itself to be the most Earth-like of the planets, with polar ice caps that grew and receded with the change of seasons, and markings that looked, to 19th-century telescopes, to be similar to human-made water canals on Earth, fueling the idea that Mars was perhaps inhabited.



Evidence of dried riverbeds, such as this fossilized dendritic drainage system, indicate the planet was once warmer and wetter.

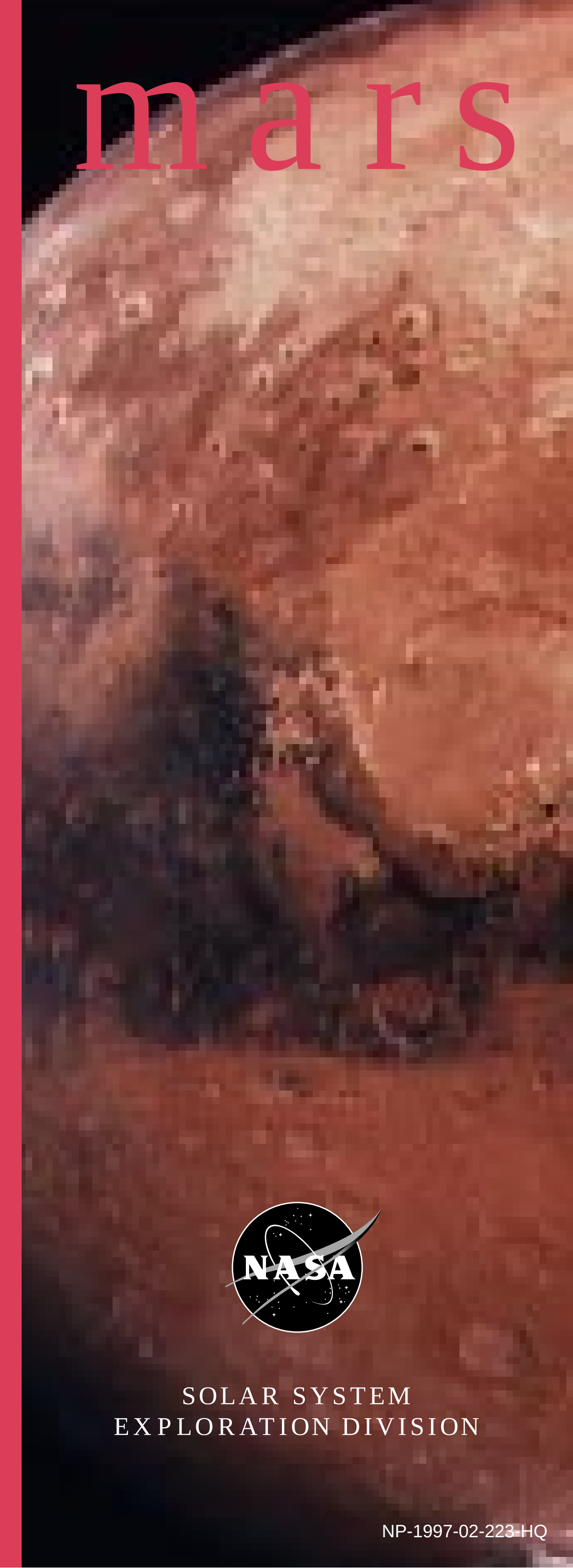
Today, we know there are no canals on Mars, but there are natural channels apparently carved by past water flow. We know there are no civilizations, and it is unlikely that there are any extant life forms, but there may be fossils of life forms from a time when there was water. These intriguing possibilities are only a small part of our broad scientific interest in the Red Planet—an interest fueled by the findings of modern spacecraft and instruments. We have learned that Mars, like Mercury, Venus, and Earth, is a small (in solar system terms), rocky planet that developed relatively close to the Sun. Mars has been subject to some of the same planetary processes—volcanism, impact events, and atmospheric effects—associated with the formation of the other "terrestrial" planets. But unlike Earth, Mars retains much of the surface record of its evolution and history. For millions of years, the Martian surface has been bare of water, and not subjected to the erosions and crustal plate movement that continually resurface Earth. So, Mars today can reveal to us the geologic history of a terrestrial planet in a way that Earth cannot. From Mars, we can learn things about our home planet that our home planet cannot teach us.

Our sense of what we can learn from Mars has been both expanded and refined as we have studied the planet over the last three decades. Today, we know the Martian climate has indeed changed, and the planet's surface has lost what liquid water it once had. Layered terrains near the Martian poles suggest that the planet's climate changes have been periodic, perhaps caused by a regular change in the planet's orbit. If this is so, we need to know more. The surface of Mars is intriguing. The planet is smaller that Earth, but its surface is dominated by a few features, larger than any terrestrial counterparts—a string of huge volcanoes sitting atop a bulge the size of the United States, an equatorial rift valley more than 4,800 kilometers long, and a planet-encircling cliff separating northern plains from southern highlands. The surface of Mars tells a tale of planetary formation we are yet to understand. Tectonism—the geological development and alteration of a planet's crust—has on Earth been in the form of sliding plates that grind against each other in some area and spread apart in the seafloors. But Martian tectonism seems to have been mostly vertical, with hot lavas pushing upwards through the crust to the surface. We need to know more about these processes if we are to fully understand what has happened—and may happen—on Earth.

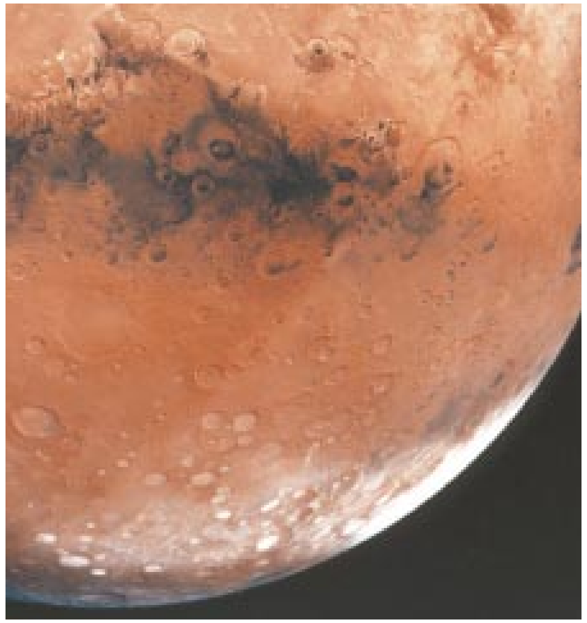
the martian fleet

Spacecraft	Launch	Accomplishments
Mariner 4 (USA)	1965	*Flyby.* First close-up pictures of surface.
Mariner 6 (USA)	1969	*Flyby.* High-resolution photos of equatorial region.
Mariner 7 (USA)	1969	*Flyby.* High-resolution photos of southern hemisphere.
Mariner 9 (USA)	1971	*Orbiter.* Year-long mapping mission, detailed photos of Phobos and Deimos.
Mars 2 (USSR)	1971	*Orbiter.* Dropped a capsule to the surface.
Mars 3 (USSR)	1973	*Orbiter and Lander.* First TV pictures from the surface of another planet.
Mars 5 (USSR)	1973	*Orbiter.* High-quality photos of southern hemisphere region.
Viking 1 (USA)	1975	*Orbiter and Lander.* First sustained surface science.
Viking 2 (USA)	1975	*Orbiter and Lander.* Discovered water frost on surface.
Phobos (USSR)	1988	*Orbiter.* Returned pictures of Phobos.
Mars Global Surveyor (USA)	1996	*Orbiter.* Global, multispectral mapping mission. Two-year mapping effort begins in 1998.
Mars Pathfinder (USA)	1996	*Lander with Rover.* First of a new generation of small, light-weight planetary craft. Paves way for following Mars missions. *Sojourner* rover provides technology demonstration and an imaging science package for surface studies.
Mars Surveyor '98 Orbiter (USA)	1998	*Orbiter.* Completes scientific reconnaissance begun by Mars Global Surveyor. International participation.
Mars Surveyor '98 Lander (USA)	1998	*Lander.* Explores high Martian latitudes where polar ices form. International participation
Planet-B (Japan)	1998	*Orbiter.* Will study interaction of solar wind with Martian atmosphere.
Future Mars Surveyors (USA)	2001–2007	*Orbiter/Lander Suites.* Launching at 2-year intervals, with international participation. Lightweight sciences packages, with possible inclusion of rovers and sample return in 2005 with possible international partners.

d i s c o v e r i n g



missions of discovery

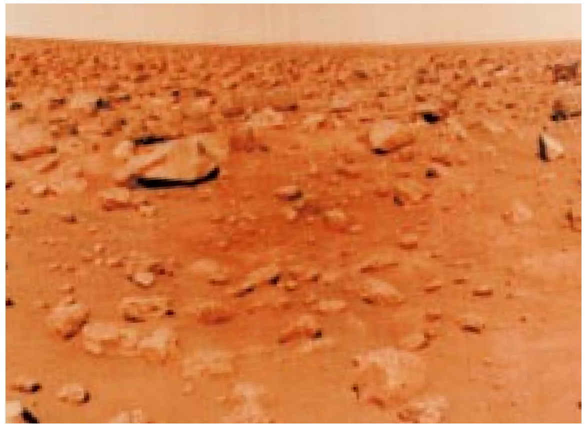


Many impact craters are visible in this Viking orbiter image, confirming that Mars has long been geologically inactive.

Most of our current knowledge of Mars is the result of investigations conducted by a fleet of spacecraft beginning with the Mariners in the mid-1960s (see the table, "The Martian Fleet"). The Mariner 4, 6, and 7 flyby missions returned photos and weather data from the southern hemisphere of Mars that put to rest hopes of finding a civilization, and that gave the impression that Mars, like the Moon, has long been geologically inactive. The data from the 1971 Mariner 9 orbital mission created quite a different picture. Looking at the entire planet, Mariner 9 revealed huge volcanic mountains in the northern Tharsis region, so large that they deformed the planet's sphericity. One of these, Olympus Mons, at more than 26 kilometers high (above Martian "sea-level"), remains the largest volcano observed in our solar system. Mariner 9 also revealed the awesome Vallis Marineris, a gigantic equatorial rift valley deeper and wider than the Grand Canyon and longer than the distance from New York to Los Angeles! Mariner 9 also gave us our first views of the Martian moons Phobos and Deimos, two asteroid-like bodies that may in fact be asteroids captured by Martian gravity.

Although Mariner 9 photos showed none of the fabled irrigation canals, the mission did disclose evidence of surface erosion and dried riverbeds, indicating the planet was once capable of sustaining liquid water. This fueled the possibility that life may be (or have been) possible on Mars. To investigate, two Viking spacecraft were dispatched to Mars in 1975. Each consisted of an orbiter and a lander. The orbiters surveyed the planet while the landers monitored surface weather conditions, took pictures, and tested the soil for signs of life. Viking 1's photos revealed reddish desert-like landscape blanketed with rocks and dune-like drifts of dust. Some 5,000 kilometers away, Viking 2 observed a slightly more rolling, duneless landscape, where patches of frost covered the ground in the Martian winter. From the weather stations, we quickly learned that these regions of Mars are too cold, and the atmosphere too thin, for liquid water to exist. The experiments designed to test for life showed some intriguing chemistry, but no signs of life.

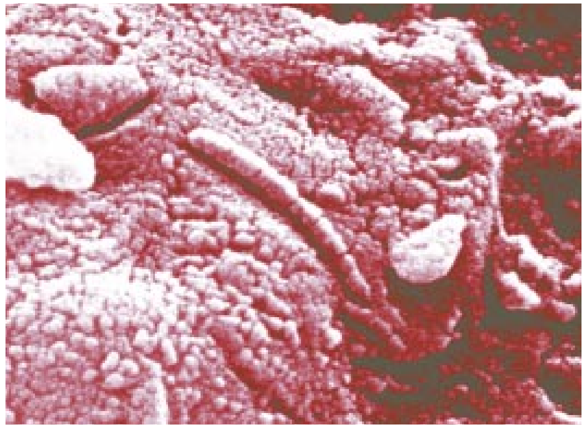
Using the best technology available in their time, the Mariners and Vikings helped address centuries-old questions about Mars. But many new questions have arisen in the years since then. Today, we seek to understand Mars as a planetary system akin to our own Earth.



The Viking landers returned photographs of desert-like landscape. The reddish coloration is caused by the chemical weathering of iron-rich rocks.

remaining questions

Our studies of Mars to date have left us with a sense of what we can learn from the Red Planet in the years to come. Recent studies of meteorites believed to have originated on Mars suggest that there may be mineral evidence of primitive life forms in the soils and rocks of the Martian terrain. Confirmation of the ancient presence of such life forms would provide powerful keys to new understandings of the origins of life in our solar system. Understanding climate change is also a critical issue for life on Earth. We need to fully understand when the Martian climate has undergone change, why, and what happened. The past presence of water required a denser atmosphere than now exists. What happened to that atmosphere? Where did the surface water go? These questions cannot be understood in isolation from others. Has the periodic change in Martian climate been caused by a regular fluctuation in the Martian orbit? If so, what causes that fluctuation? Is there a relation to terrestrial phenomena, such as our ice ages? How have volcanism and impacts from comets and meteorites created the terrains we see today in the southern highlands and northern lowlands of Mars? What is the tectonic history of the planet. Is Earth alone among the terrestrial planets in exhibiting plate tectonics? Why? The answers to these and other questions about the Red Planet await the next generation of Mars explorers.

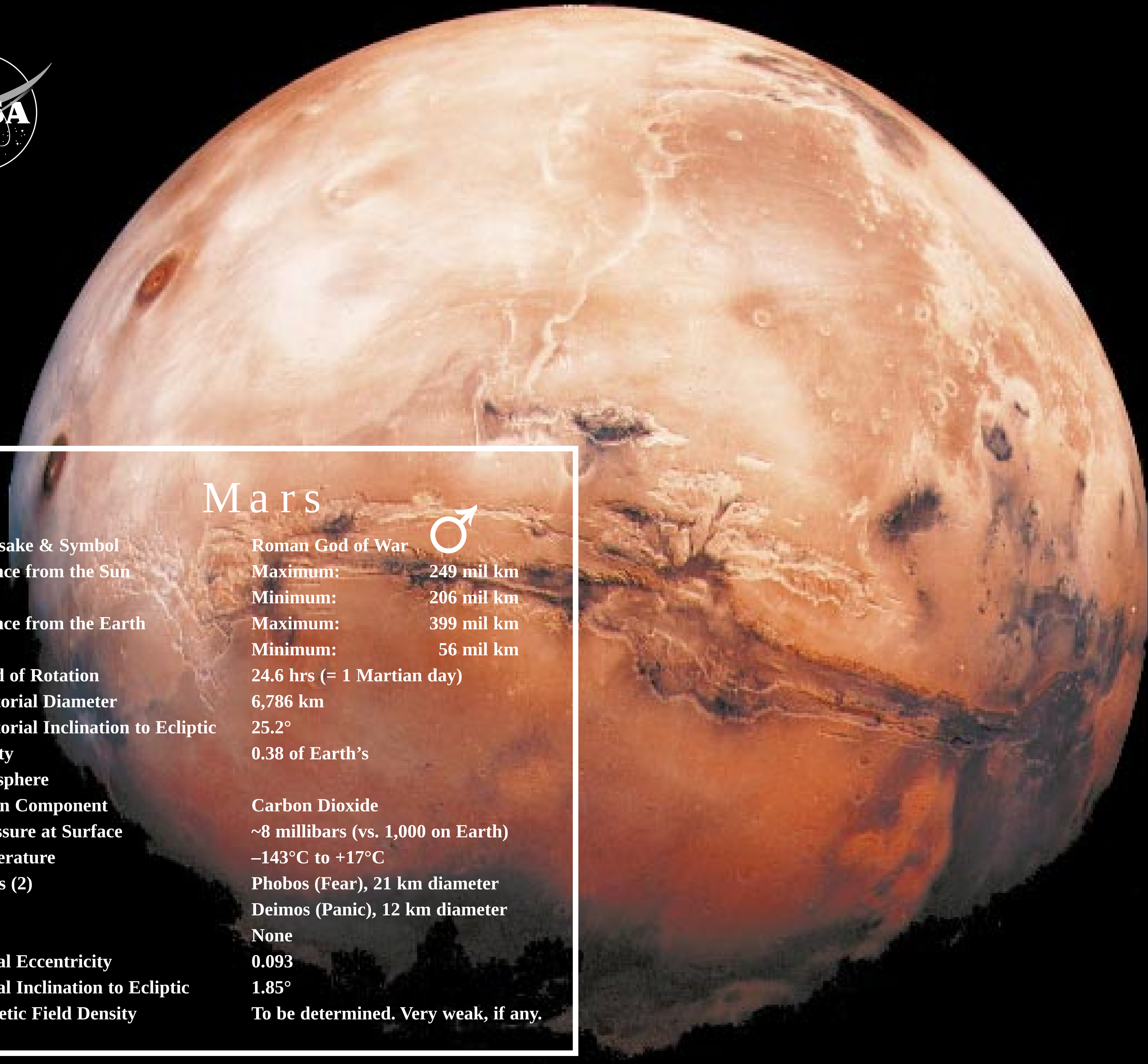


This high-resolution scanning electron microscope image shows an unusual tube-like structural form that is less than 1/100th the width of a human hair in size found in a meteorite believed to be of Martian origin.

the next generation

In 1996, Mars Pathfinder and Mars Global Surveyor launched the next wave of Mars exploration. The Pathfinder approach demonstrates new, lightweight, low-cost lander, rover, and imaging technologies while characterizing Martian soils and rocks in the vicinity of the landing site. Mars Global Surveyor inaugurates an ambitious program of orbital science to recapture the science lost with the Mars Observer spacecraft. Martian weather, seasonal change, surface features, and composition will be studied in detail over Mars Global Surveyor's 2-year mapping phase, providing our first comprehensive, high-resolution look at the near-surface and surface phenomena on Mars. These missions set the stage for the Mars Surveyor series, which will send similarly lightweight orbiters and landers to Mars every 2 years into the first decade of the next century. Orbiters will provide synoptic coverage of areas and phenomena of interest, while acting as data relay stations for landers. Landers will probe the soils and test the rocks in search of clues regarding the origins and evolution of the Red Planet, and will look for tell-tale signs of life forms, past and present. We envision the Mars Surveyor program as the linchpin for NASA participation in all future international Mars exploration programs.

Although to date Mars exploration missions have been conducted on a national scale by the United States and Russia, the allure of Mars is international in scope. Data exchange from previous planetary missions is already international, and other nations are now planning Mars missions for the next decade (see the table, "The Martian Fleet"), some of which will include international cooperation. Mars may have been named for the god of war, but the day is fast approaching when international expeditions will investigate the Red Planet in the name of peace.



Mars

Namesake & Symbol	Roman God of War ♂
Distance from the Sun	Maximum: 249 mil km
	Minimum: 206 mil km
Distance from the Earth	Maximum: 399 mil km
	Minimum: 56 mil km
Period of Rotation	24.6 hrs (= 1 Martian day)
Equatorial Diameter	6,786 km
Equatorial Inclination to Ecliptic	25.2°
Gravity	0.38 of Earth’s
Atmosphere	
Main Component	Carbon Dioxide
Pressure at Surface	~8 millibars (vs. 1,000 on Earth)
Temperature	–143°C to +17°C
Moons (2)	Phobos (Fear), 21 km diameter
	Deimos (Panic), 12 km diameter
Rings	None
Orbital Eccentricity	0.093
Orbital Inclination to Ecliptic	1.85°
Magnetic Field Density	To be determined. Very weak, if any.