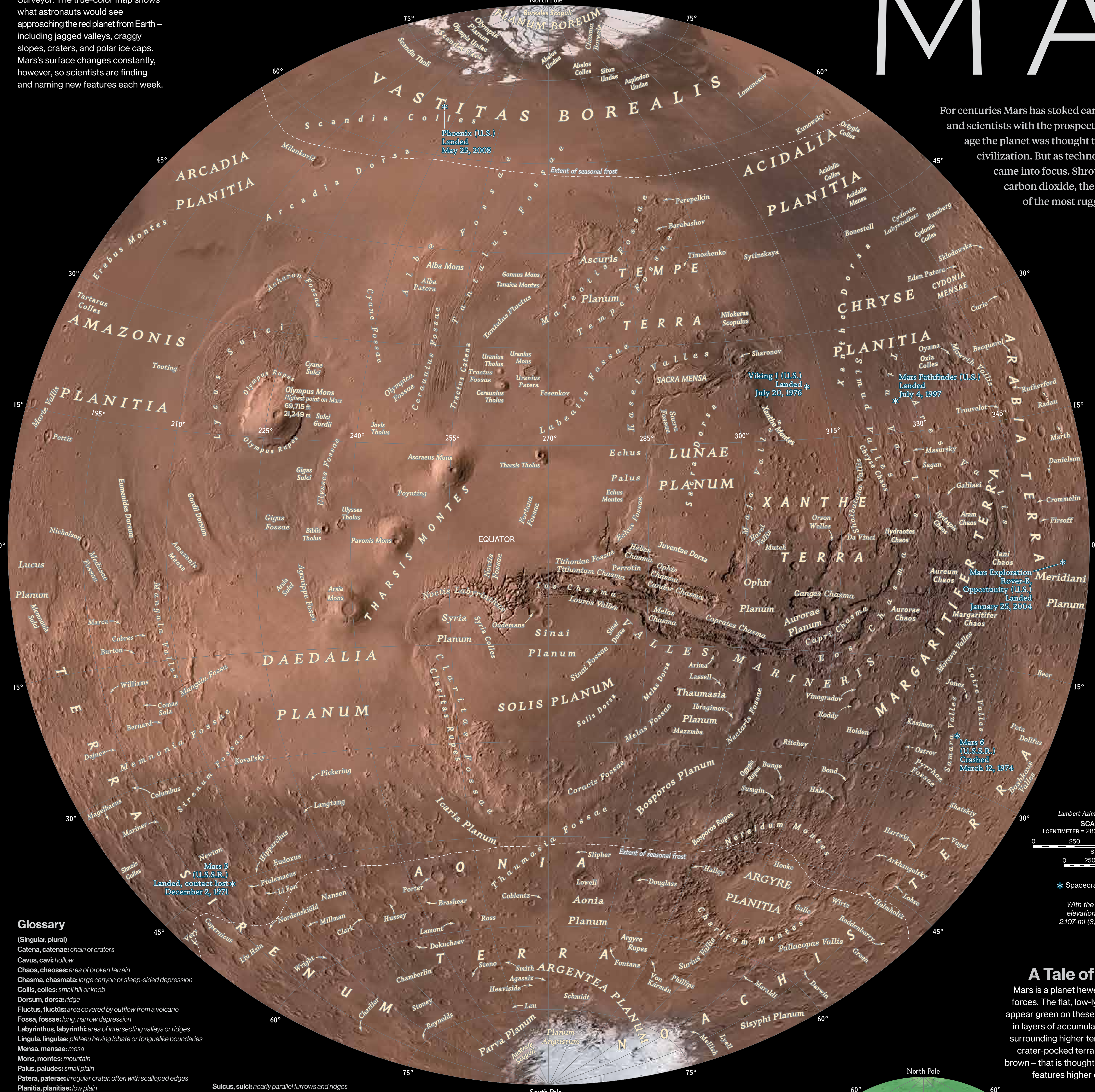
This view of Mars is a mosaic comprising thousands of photographic images from NASA's Mars Global Surveyor. The true-color map shows what astronauts would see approaching the red planet from Earth – including jagged valleys, craggy slopes, craters, and polar ice caps. Mars's surface changes constantly, however, so scientists are finding and naming new features each week.

MARS

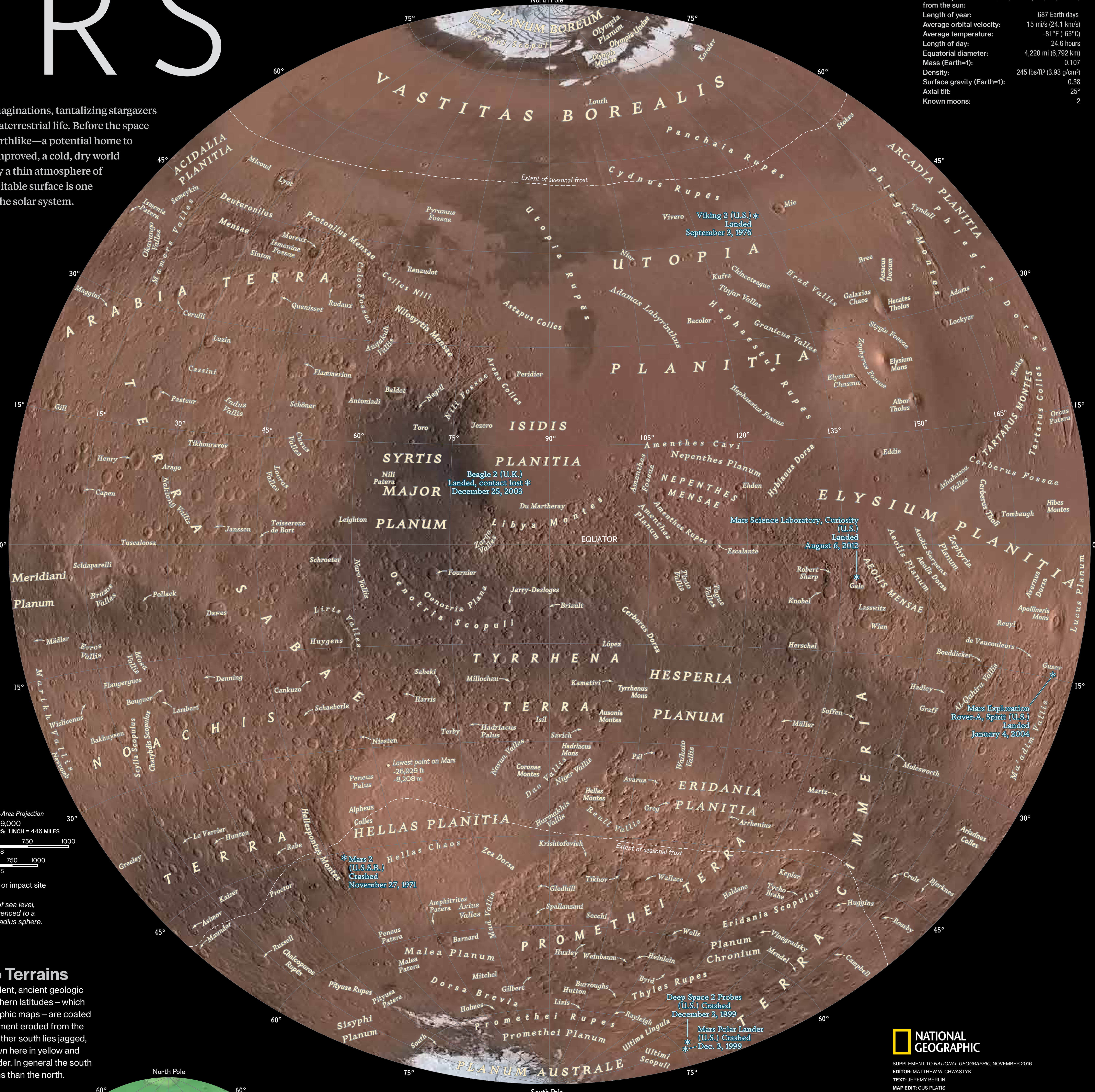
For centuries Mars has stoked earthly imaginations, tantalizing stargazers and scientists with the prospect of extraterrestrial life. Before the space age the planet was thought to be Earthlike—a potential home to civilization. But as technology improved, a cold, dry world came into focus. Shrouded by a thin atmosphere of carbon dioxide, the inhospitable surface is one of the most rugged in the solar system.

Average distance from the sun:	141,637,725 mi (227,943,824 km)
Closest point to the sun:	128,409,598 mi (206,655,215 km)
Farthest point from the sun:	154,865,853 mi (249,232,432 km)
Length of year:	687 Earth days
Average orbital velocity:	15 mi/s (24.1 km/s)
Average temperature:	-81°F (-63°C)
Length of day:	24.6 hours
Equatorial diameter:	4,220 mi (6,792 km)
Mass (Earth=1):	0.107
Density:	245 lbs/ft³ (3.93 g/cm³)
Surface gravity (Earth=1):	0.38
Axial tilt:	25°
Known moons:	2

Western Hemisphere



Eastern Hemisphere



Lambert Azimuthal Equal-Area Projection
SCALE 1:28,249,000
1 CENTIMETER = 282 KILOMETERS; 1 INCH = 446 MILES
0 250 500 750 1000 STATUTE MILES
0 250 500 750 1000 KILOMETERS

* Spacecraft landing or impact site

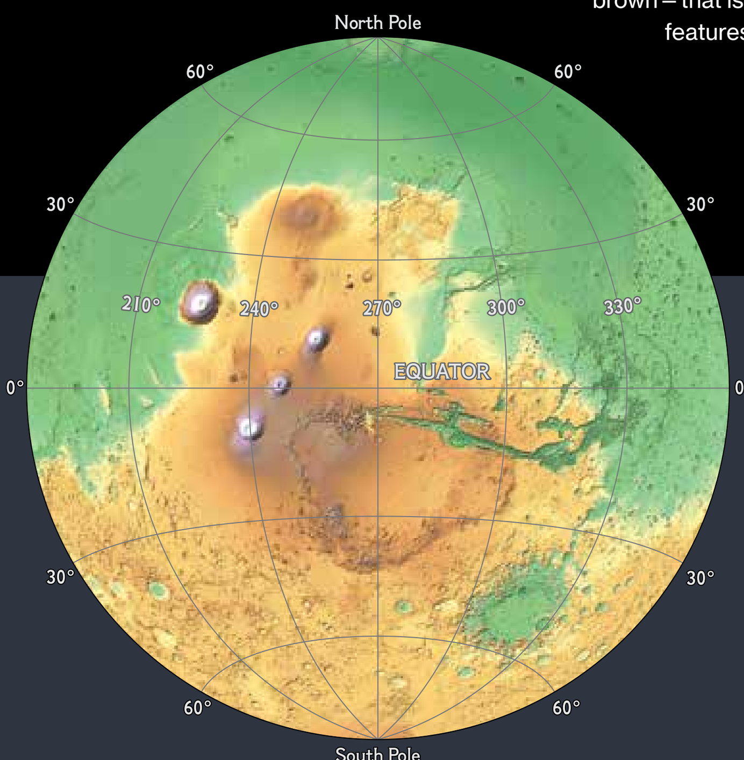
With the absence of sea level, elevations are referenced to a 2,107-mi (3,390-km) radius sphere.

Glossary

(Singular, plural)
Catena, catenae: *chain of craters*
Cavus, cavi: *hollow*
Chaos, chaoses: *area of broken terrain*
Chasma, chasmata: *large canyon or steep-sided depression*
Collis, colles: *small hill or knob*
Dorsum, dorsa: *ridge*
Fluctus, fluctūs: *area covered by outflow from a volcano*
Fossa, fossae: *long, narrow depression*
Labyrinthus, labyrinthi: *area of intersecting valleys or ridges*
Lingula, lingulae: *plateau having lobate or tonguelike boundaries*
Mensa, mensae: *mesa*
Mons, montes: *mountain*
Palus, paludes: *small plain*
Patera, paterae: *irregular crater, often with scalloped edges*
Planitia, planitiae: *low plain*
Planum, plana: *plateau or high plain*
Rupes, rupēs: *scarp*
Scopulus, scopuli: *lobed or irregular scarp*
Serpens, serpentes: *sinuous feature with segments of raised and depressed elevation*
Sulcus, sulci: *nearly parallel furrows and ridges*
Terra, terrae: *extensive area*
Tholus, tholi: *small, dome-shaped mountain or hill*
Unda, undae: *dune*
Vallis, valles: *valley*
Vastitas, vastitates: *extensive plain*

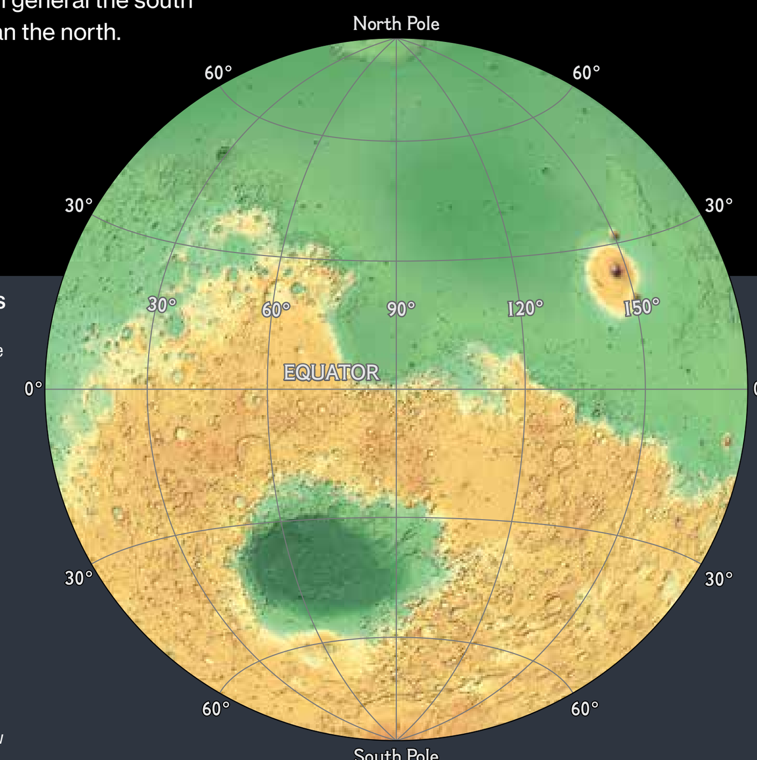
A Tale of Two Terrains

Mars is a planet hewed by violent, ancient geologic forces. The flat, low-lying northern latitudes – which appear green on these topographic maps – are coated in layers of accumulated sediment eroded from the surrounding higher terrain. Farther south lies jagged, crater-pocked terrain – shown here in yellow and brown – that is thought to be older. In general the south features higher elevations than the north.



Elevation

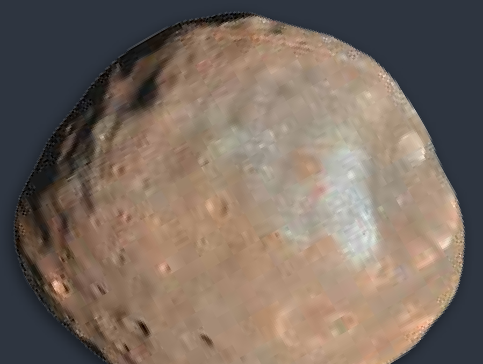
FEET	METERS
69,715 ft	21,249 m
52,493	16,000 and above
39,370	12,000
26,247	8,000
13,123	4,000
0	0
-13,123	-4,000
-26,247	-8,000 and below
-26,929 ft	-8,208 m



NATIONAL GEOGRAPHIC
SUPPLEMENT TO *NATIONAL GEOGRAPHIC,* NOVEMBER 2016
EDITOR: MATTHEW W. CHWASTYK
TEXT: JEREMY BERLIN
MAP EDIT: GUS PLATIS
RESEARCH: TARYN SALINAS
SOURCES: NASA; GAZETTEER OF PLANETARY NOMENCLATURE, PLANETARY GEOMATICS GROUP, USGS; NASA/JPL; UNIVERSITY OF ARIZONA; JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY; CARNEGIE INSTITUTION OF WASHINGTON; ROSALYN HAYWARD, JAMES SKINNER, AND KENNETH TANAKA, ASTROGEOLOGY SCIENCE CENTER, USGS

PRINTED AUGUST 2016

Misshapen Martian Moons



Phobos

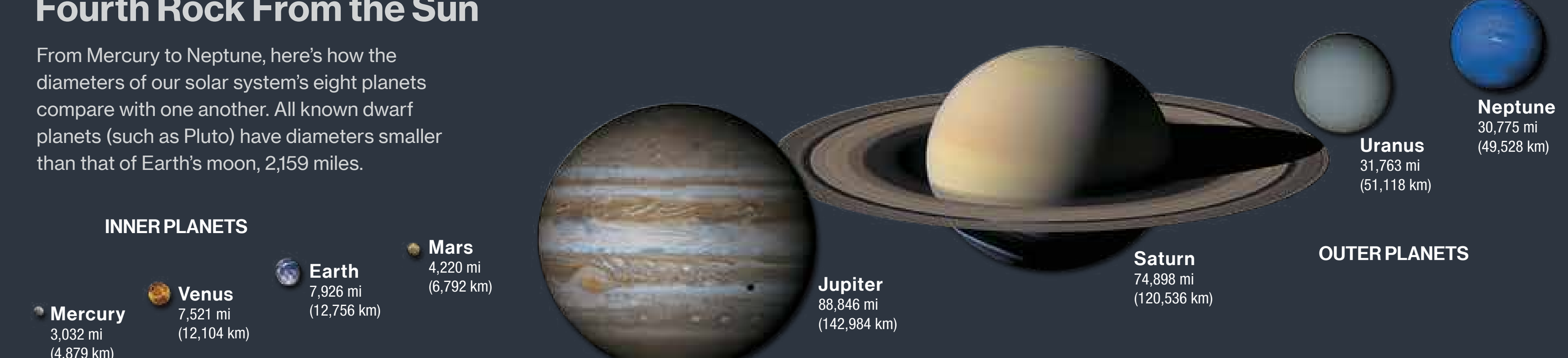
This irregularly shaped moon circles Mars three times a day, orbiting 3,700 miles from the planet's surface. It's small as moons go – averaging only 13.8 miles across.

Deimos

This tiny moon orbits Mars at an average distance of 14,580 miles. Some scientists say the eight-mile-wide satellite may be an asteroid captured by the planet's gravity.

Fourth Rock From the Sun

From Mercury to Neptune, here's how the diameters of our solar system's eight planets compare with one another. All known dwarf planets (such as Pluto) have diameters smaller than that of Earth's moon, 2,159 miles.



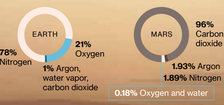
The Challenge of an Unforgiving World

A key step in the journey to Mars is to orbit it, which NASA hopes will happen in the 2030s. But landing, surviving, and ultimately thriving on the red planet – with its low gravity level, seesawing temperatures, and nearly oxygen-free atmosphere – present myriad issues for human colonists.

The diameter of the sun appears 34 percent smaller on Mars.

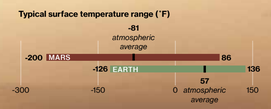
ATMOSPHERE

Today Mars has an atmospheric pressure that is just 0.6 percent of Earth's, which isn't enough to hold a body of water in place. A more robust atmosphere may once have supported large bodies of water, yet something – perhaps solar radiation, the impact of an asteroid, a change in the magnetic field – made oceans impossible.



TEMPERATURE

Like Earth, Mars has days and nights, weather patterns, distinct seasons, and polar ice caps. But while its midlatitudes can be temperate at times, its thin air and vast distance from the sun – one Martian orbit takes nearly two Earth years to complete – make it susceptible to wild temperature swings.

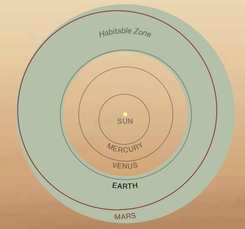


VOLUME AND MASS

Mars's planetary volume is 15 percent of Earth's; its mass is 11 percent. According to the laws of Newtonian physics, gravity on Mars is about a third of that on Earth. This means astronauts there could lose a lot of the skeletal and muscle mass they developed fighting Earth's gravity. It also means that launching a spaceship from Mars would take less energy.

DISTANCE

Earth lies near the inner edge of the solar system's habitable zone, defined as the range of distances from a star, in this case the sun, where a planet can sustain liquid water (with enough atmospheric pressure to keep it in place). Mars sits within the habitable zone too, but closer to the outer edge.



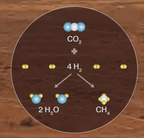
NATIONAL GEOGRAPHIC

COLONIZING MARS

Could humans live on Mars? One day, perhaps. But establishing settlements there would be a forbidding task. The vision shown here is drawn from the National Geographic Channel's global event series on Mars. It reflects what some scientists are thinking right now, based on the most recent research. Time will tell if it's a blueprint for living on the red planet.

Solutions for Survival

The more resources we can find – or create – to make Mars habitable, the fewer we'd have to bring from Earth. Scientists are now studying ways to use what already exists on Mars. To establish a colony, humans would need to be able to supply five things: oxygen, water, shelter, food, and energy.



FUEL

METHANE GENERATION

A return to Earth would require fuel production on Mars. The efficient Sabatier process combines carbon dioxide with hydrogen at a high temperature in the presence of a nickel catalyst to release methane and water. Water molecules could then be further reduced into hydrogen and oxygen.

WATER

EXTRACTING WATER FROM AIR

Although Martian air is more than 95 percent carbon dioxide, it does contain traces of water to harvest. Beds of a mineral called zeolite would extract moisture from the air. Once saturated, the beds could be microwaved to vaporize the water, which would then condense, freeze, and be stored as ice.

WATER

GETTING GROUNDWATER

In addition to the ice on Mars's surface at high latitudes, there might be a great deal of frozen water within the soil closer to the planet's equator. Microwaving the soil could melt and extract the water.

Maintenance shed

ENERGY

POWER FROM THE SUN

Solar energy would be a logical resource for creating electricity on Mars. But harvesting sunlight would be more difficult than it is on Earth, not only because of the planet's distance from the sun but also because of Mars's massive dust storms. So other power sources would need to be developed.

Solar panels

ENERGY

PORTABLE POWER

Spacecraft and the precise scientific instruments they carry require safe, reliable, long-lasting power systems. One source that could generate the necessary juice is a nuclear battery – a radioisotope thermoelectric generator – that converts heat into electricity.

ENERGY

NUCLEAR POWER

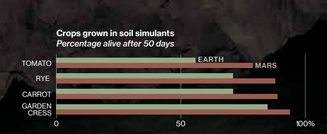
NASA developed a power-producing system that could be used on many planets and asteroids. A fission reaction in a nuclear reactor would produce electricity. Surrounded by a radiation shield, the reactor would be connected to the base by a cable, delivering power at any time of day, under any atmospheric conditions.

Nuclear fission reactor
The reactor would be buried under the surface. extended panels would shed excess heat.

FOOD

MARTIAN GREENHOUSES

Ecologists have tested 14 plants in soil produced to match the chemical composition of Martian soil, which contains all essential nutrients for plants to grow, including phosphorus, nitrogen, potassium, and iron. But for plants on Mars to maintain the kind of growth shown at right, agronomists would need to engineer soil that is more water efficient and nitrogen rich.



Greenhouse

Common area

Lab

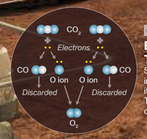
Corridor

Dorm

OXYGEN

BETTER BREATHING THROUGH CHEMISTRY

Scientists could collect the abundant carbon dioxide gas in Mars's atmosphere, compress it, and use electricity to split its molecules into oxygen and carbon monoxide molecules. The oxygen would be tested for purity and stored, and the carbon monoxide vented back into the atmosphere.



SHELTER

LIVING IN LAVA TUBES

Lava tubes are cave-like conduits formed underground by cooled, hardened lava after molten rock has flowed through. Scientists say the ones on Mars may be significantly larger than those on Earth. The interiors of the Martian tubes, hidden under dozens of feet of solid rock, are protected from cosmic and solar radiation and fluctuating temperatures on the harsh, dusty surface.

COMMUNICATION

Point-to-point communication on Mars would be via radio waves. To avoid obstructions, signals would have to be beamed to orbital satellites and then relayed back to the ground.

WATER

HIDDEN GLACIERS

Ground-penetrating radar from NASA's Mars Reconnaissance Orbiter has revealed massive glaciers of frozen water preserved beneath rocky debris at much lower latitudes than where ice had been previously identified. These glaciers extend for dozens of miles.

MARS

To learn more about colonizing the red planet, tune in to the Channel's global event series, *MARS*, on November 14 at 9/8c.

For related educational resources go to *natgeoed.org/mars*.

SUPPLEMENT TO NATIONAL GEOGRAPHIC, NOVEMBER 2016
EDITOR: JASON TREAT ART: DYLAN COLE
RESEARCH: MANYUN ZOU, TAPTU SALIMS
TEXT: JEREMY BERLIN
SOURCES: ROBERT BRAUN, GEORGIA INSTITUTE OF TECHNOLOGY; NASA/JPL; RAVI KUMAR KOPPARAPU, NASA GODDARD SPACE FLIGHT CENTER; ANTHONY MUSCATELLO AND EDGARDO SANTIAGO, NASA; ADAM BRUCKNER, UNIVERSITY OF WASHINGTON; MICHAEL HEIGHT, MIT HAYSTACK OBSERVATORY; WIEGER WAMELINK, WAGENINGEN UNIVERSITY AND RESEARCH CENTRE, NETHERLANDS