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On Mars

You skip southward lightly in reduced gravity; red dust puffs upward where the boots of your pressurized body suit touch the ground. A plastic cup of icy cola, grasped firmly in your glove, boils violently in the thin poisonous air. The early-morning sky is pink all around, mutedly illuminated by a small-looking Sun, rising to your left. You stop at what seems to be the edge of the world: a stomach-dropping cliff falls away to an arid floor miles below you. Far off to the south, dimly visible through a morning haze of ice crystals, is another mammoth wall. The chasm extends out of sight toward the rising Sun. To your right, a distant mountain top rises impossibly high; a wisp of white carbon dioxide ice condenses downwind from its summit. Another morning dawns on Mars.

Getting to Know Mars

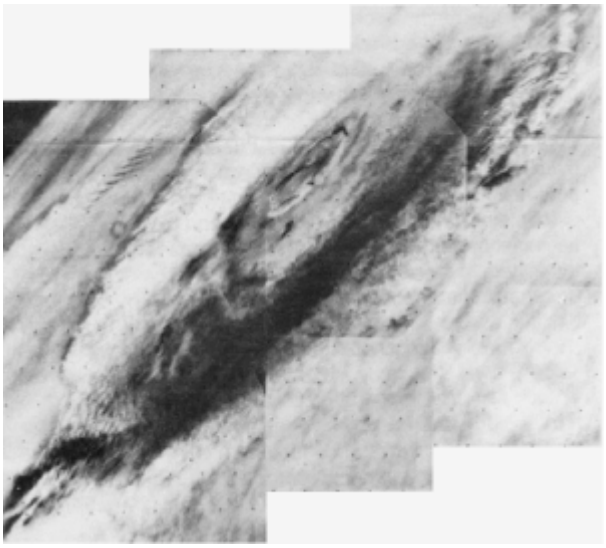
Our neighbor planet is a fascinating place, a world that is both tantalizingly familiar and strangely different. Since Mars will be closer to Earth, brighter, and easier to spot in the sky in the fall of 1988 than it has been for many years, this coming school year will be a perfect time to acquaint your students with Mars's history and geography and its important place in our exploration of the solar system.

The Orbit of Mars

Half again as far from the Sun as we are, Mars takes about 687 Earth days to travel around our star. This turns out to mean that it returns to the same position against the backdrop of the stars as seen from Earth every 2.14 Earth years. The best time to see Mars in the sky is when it is at *opposition*, on the opposite side of Earth from the Sun. This is when the red planet is closest to us — and thus looks biggest and brightest — and also when it is in the sky all night long.

To make matters just a bit more complicated, Mars's orbit is slightly eccentric, which means that it is not at the same distance from us at every opposition — it can be as far away as 101 million kilometers (63 million miles) and as close as 56 million kilometers (35 million miles) — quite a range!

The closest close approaches — called favorable oppositions — come every 15 to 17 years on average. The last favorable opposition was in 1971 (how many of your students had even been born then?), but the 1988 one will be one of the best in the 20th century. On September 22, Mars will be only 58.6 million kilometers (36 4 million miles) from Earth, only about 2.9 million kilometers farther than the record closest approach. Mars should be very easily visible in the night sky — a brilliant crimson point of light, beckoning to us as it has for centuries.



Olympus Mons on Mars. (NASA photo)

Air and Weather on Mars

Only robot spacecraft have visited Mars so far, the most noteworthy being the two *Viking* probes in 1976, each of which consisted of an orbiter and lander. Still, some scientists and space enthusiasts have already begun to plan for a human journey to the red planet in the next century. Perhaps one of your students will be among the first to go. What will the first Martian visitors find?

To begin with, the planet's atmosphere and weather are very hostile — and in quite different ways from the wet, stormy hazards Earth's climate poses. The most dangerous thing about the atmosphere of Mars (to humans) is that it's very thin. As measured by the weather stations on the U.S. Viking probe landers, Mars's pressure varied between .006 and .015 of Earth's. Such a near-vacuum would have a peculiar effect on liquid water: if the temperature is even just a little above freezing, a pool of water — or the water in a human's bloodstream — would quickly come to a boil.

The boiling point of water (or any other liquid) depends in large part on the weight of atmosphere pushing down on it. The higher the pressure, the harder water has to "work" (the higher its temperature has to be) in order for it to boil. That's how pressure-cookers work: by sealing a pot of water under high pressure, the water reaches a higher temperature before it boils, and potatoes can cook faster. Mars can be thought of as a pressure cooker in runaway reverse; the boiling point of water on Mars is very close to the freezing point, and a glass of water at room temperature would bubble away vigorously and quickly.

Even if protected by a pressure suit, a tourist on Mars would have to contend with other strange inconveniences. Imagine our tourist trying to boil water over a campfire. First, she'd find no liquid water — it's all either frozen solid or a *very* thin vapor in the air. Second, she'd find no fuel for her campfire: no trees, no twigs, no organic material of any kind. Most frustratingly, though — even if she brought her own water and her own newspapers to light with matches — *nothing would burn!* Mars's air contains virtually no oxygen at all, and oxygen is necessary for fires. (Of course, this means that our tourist would need to have oxygen tanks in order even to breathe!) The atmosphere of Mars is about 95% carbon dioxide; oxygen makes up only about 1/10th of 1%. (Earth's air is roughly 80% nitrogen and 20% oxygen.)

Even a suitably protected and supplied tourist would find Mars's weather to be a little tough. Martian temperatures are brutally cold, as a rule. In their six years of operation on the surface from 1976 to 1982, the two *Viking* landers seldom recorded any temperature higher than about *minus* 30 degrees Celsius (20 degrees below zero Fahrenheit). While it never rains on Mars, there are storms: but they are *sand* storms. Periodically (about every Martian year or so), the entire planet is choked by global, sandblasting dust storms that shroud its entire surface. Even when no sandstorm is in progress, there is enough red Martian dust in the air to turn the sky pink in the daytime.

The Land: Awesome Scale, Eerie Scenes

Despite the hardships it would pose to humans, Mars would be a fascinating place to visit. Even though it's a small world (only about half the diameter of our planet), Mars has about as much dry *land* area as the Earth does (since most of our surface is under water), and its variety of scenery is at least as diverse as ours. A travel agency's Mars brochure would certainly highlight these attractions:

- **Ancient Craters**

Vast areas of Mars, especially in the southern hemisphere, are saturated with bowl-shaped *craters*, most of which were blasted out when the planet was bombarded by chunks of interplanetary debris billions of years ago. These craters can be huge — one, called the "Hellas Basin,'' is more than 1600 kilometers wide and six kilometers deep (a thousand miles across and four miles deep). Somewhat softened now by billions of years of gentle erosion, these blast-pits are mute reminders of the violence that accompanied the youth of our solar system, when no one had "cleaned up'' after the planets formed, and bits and pieces of residual debris (called *planetesimals*) rushed helter-skelter through space, colliding frequently with the infant planets. Earth, too, must have endured the early bombardment, but our planet's vigorous erosion and rapid surface activity (such as volcanism and continental drift) have erased the record of our world's youth.

- **Towering Volcanoes**

While some areas of Mars have been changed very little since those early days of bombardment, there are areas that have experienced some striking geological activity since then. Perhaps most spectacular are the volcanoes of Mars — many of which dwarf those on Earth — which have thrust through and covered up some of the ancient cratered terrain. One northern hemisphere area called the "Tharsis Bulge'' contains the most impressive array of volcanic mountains known in the entire solar system. Four of Tharsis's volcanoes are so tall that their summits are virtually in space; they protrude above the top of Mars's occasional global dust storms and are then the only parts of the surface visible from afar.

The most impressive mountain in the Tharsis region is called Olympus Mons ("Mount Olympus''). This mammoth cone is about 500 kilometers (300 miles) across at its base — on Earth, it would cover Arizona or New York State — and the 80-kilometer-wide crater (or "caldera,'' as the depressions at volcano tops are called) at its summit is 25 kilometers (15 miles) above the surrounding plain. To put its height in perspective, note that the top of Mt. Everest is only about 9 kilometers above sea level.

- **A Gargantuan Chasm**

Stretching eastward from the Tharsis Bulge along the Martian equator, the grandest array of canyons in the solar system spans the width of an earthly continent. It is nearly 5,000 kilometers (3,000 miles) long, and is known as "Valles Marineris'' (the "Valleys of Mariner''), after the *Mariner 9* spacecraft in whose photographs the canyons were discovered in 1971. This great series of cracks in the Martian crust makes America's Grand Canyon look a little like an irrigation ditch in comparison. In many places, the canyons are more than 80 kilometers (50 miles) wide and their sheer walls are more than *eight kilometers* (five miles) high! This is so high that were you to look at a school bus on the canyon floor from a vantage point on its rim, the bus would appear to be about the size of a flea on the ground near you. If you were to have the misfortune to stumble and fall from the top, you'd have plenty of time to enjoy the scenery before you hit the bottom. In Mars's weak gravity (only 38% as strong as Earth's), it would take you more than 60 seconds to fall the five miles.

The Valles Marineris canyons were probably formed by a stretching of Mars's crust (akin to the geologic forces that pulled Earth's continents apart from one another) long ago, not by running water which carves the canyons we're used to on Earth.

- **Dry River Systems: Legacy of a Warmer World**

Perhaps most exciting to planetary scientists, our probes have found a tracery of channels and troughs that wind among the more immediately apparent features on Mars. These *dry river beds*, found all over the planet, were first discovered in the photographs returned by Mariner 9 in 1971 and studied in more detail by the *Viking* orbiters from 1976 to 1980. Some are "dendritic'' (branching) systems like river systems on Earth, some more closely resemble scoured areas ravaged by catastrophic floods.

As we've seen, liquid water cannot exist in large amounts on Mars now — the atmospheric pressure is just too low—but the now-arid scars of ancient rivers and floods show clearly that water could (and did) flow on the red planet's surface sometime in the past. No one is sure Just how long ago that was—in fact, it may have happened more than just once—but it is clear that Mars used to be a very different place from what it is now. It appears that in the past the air was thick enough, and the temperatures warm enough to sustain pools, rivers, rain, and floods.

(We should emphasize that the dry river channels on Mars are not the "canals'' of science fiction. Such canals — artificial waterways — apparently never existed on Mars.)

Is There Life on Mars?

It doesn't seem likely that there is life of any kind on the red planet — but it is important not to give students the impression that Mars has been proven to be sterile.

Most of the evidence concerning the question of life on Mars comes from a battery of ingenious experiments that were carried out by the *Viking* automated lander craft on Mars in 1976 (and for a few years thereafter). These experiments included cameras (which continually monitored the surface near them for large scale organisms), three micro-biology experiments (which looked for changes that microbes would cause in soil samples brought aboard), and one that looked for organic molecules that might have been left in the soil by life long ago, even if Mars is lifeless now (Earth's soil is permeated by such chemical "droppings'' of life). None of the experiments produced results that conclusively showed life to be on Mars — or ever to have been there.

Of course, the *Viking* landers could only explore their immediate environment — Lander 1 in Chryse Planitia ("the plains of gold'') at latitude 22 degrees North and Lander 2 on the plains called Utopia at latitude 48 degrees North. Scientists would like to explore many other parts of the red planet before coming to any final conclusions about the presence or history of life on Mars.

Resource Corner

1. Mars Books and Articles for Younger Students

   "Expedition Mars'' and "The Exploration of Mars'' in *Odyssey* magazine, May 1984.

   Moche, D.: *Mars.* 1978, Watts. A nice picture book for primary grades.

2. Mars Books and Articles for Teachers and Older Students

   Beatty, J. "The Amazing Olympus Mons'' in *Sky & Telescope*, Nov 1982, p. 420

   Carroll, M. "The Changing Face of Mars'' in *Astronomy*, Mar 1987, p. 6

   Cooper, H. *The Search for Life on Mars.* 1980, Holt, Rinehart & Winston

   Gore, R. "Sifting for Life in the Sands of Mars'' in *National Geographic*, Jan 1977

   Sagan, C. *Cosmos.* 1980, Random House. The chapter called "Blues for a Red Planet'' is an eloquent introduction to Mars.

   Washburn, M. *Mars At Last.* 1977, Putnam's

3. Mars Slides:

   The Mars Kit. 1987, Astronomical Society of the Pacific. Six color slides and background information.

Activity Corner

Classroom Activities and Projects about Mars

Naturally, the preferred activity while studying Mars is to find the planet in the night sky, follow its motion, and try to see it through a telescope. But for those who only teach during the day and for those times when the skies are cloudy, there are still a host of interesting Martian activities to try:

Pick the Seven Wonders of the Martian World

After studying about Mars, students should be asked to write a travelogue for prospective Martian tourists. You might try an assignment such as: If you were a travel agent, what could you say to entice travelers to pay a visit to the red planet? What do you think are the most spectacular sights on Mars and why? (Be sure you warn your tourists about hazards to expect, so you don't get sued for false advertising!)

Martians Through the Ages

Its proximity and visible features (such as varying polar caps) have long made Mars a favorite site for possible alien life forms. Science fiction writers (and some astronomers) have invented a host of Martians over the years. Students might enjoy doing a history of fictional Martians and adding a critique of each life form based on our current understanding of the red planet.

Invent a Martian

Following up on Dennis Schatz's very popular "Invent an Alien'' activity (published in the first issue of this newsletter), you might assign students the task of putting together an alien life form that could survive conditions on Mars as we know them today. Students could submit written reports, drawings, or models, and even use costumes, props, and make-up to transform themselves into plausible Martians.