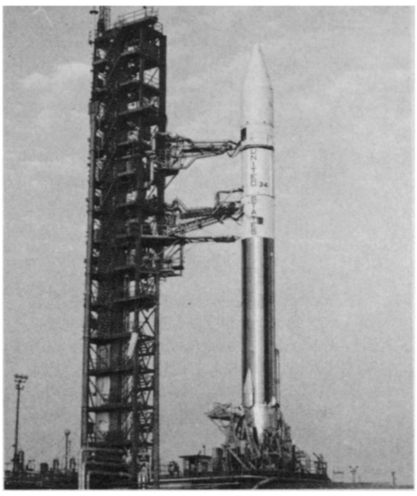


NASA

Preparations for launch of Mariner 10.

On the heels of Mercury

Mercury, the oddball planet of the solar system, holds important clues to the history of planetary evolution. Scientists will get more than a glimmer when Mariner 10 flies by Mercury in March.

by Everly Driscoll

I stood on the surface of Mercury. The huge, scorching sun glared mercilessly. No atmosphere screened its fierce radiation. The temperatures seethed above 325 degrees C. The day seemed eternal. We once thought it was, but now knew it would last only 176 earth days. The soil under my feet was similar to what I had seen on the moon. From my vantage point atop a sloping hill, I could see many craters and features that rose 600 feet above the landscape. When night finally came, after two Mercury years, the temperatures dropped to minus 123 degrees C. The darkness overhead was penetrated only by the light of distant earth, Venus, other planets and the stars.

One's imaginings of what the surface of Mercury is like—based on what is now known from the vantage point of earth—may soon be altered by a close-up look at the planet. On Nov. 3, 1973, the United States will launch the first spacecraft toward Mercury. Mariner 10 should pass within 635 miles of the closest planet to the sun. The journey will be a comprehensive tour of the inner solar system—a two-planet mission to take scientific instruments and cameras past Venus in February 1974 (SN: 8/4/73, p. 72), past Mercury in March, then around the sun and back past Mercury two more times: in September 1974 and again in March 1975. By then if Mariner's equipment holds out, earthlings won't have to imagine what Mercury is like. They'll know.

"Now Mercury is the least known of any planet in the solar system except for Pluto," says Robert G. Strom of the University of Arizona. Mercury's small size and proximity to the sun have kept it less familiar to earthlings than even Jupiter and Saturn. The angle between Mercury and the sun—less than the angle between the hands of a watch at one o'clock—makes viewing difficult. The planet can be seen very low on the horizon just before sunrise and after sunset, but at that low angle its light has to pass through a much greater thickness of earth's atmosphere, and this makes study difficult. Most scientists thus view Mercury in broad daylight in spite of the sun's glare.

Mercury is the smallest of the planets, its diameter not much wider than the Atlantic Ocean at its widest point. It is only a little larger than the moon. It is also probably the densest of the planets. Scientists think it is about half iron, which makes it an oddball in the solar system.

Unknowns include the exact radius, the surface pressure, the constituents in the tenuous atmosphere and the magnetic field. Sketches have been made of the dark markings on the surface, but little detail can be distinguished.

Interest about Mercury has intensified over the last decade as radar, spectral-reflectivity and polarization studies have corrected some age-old misconceptions about the planet.

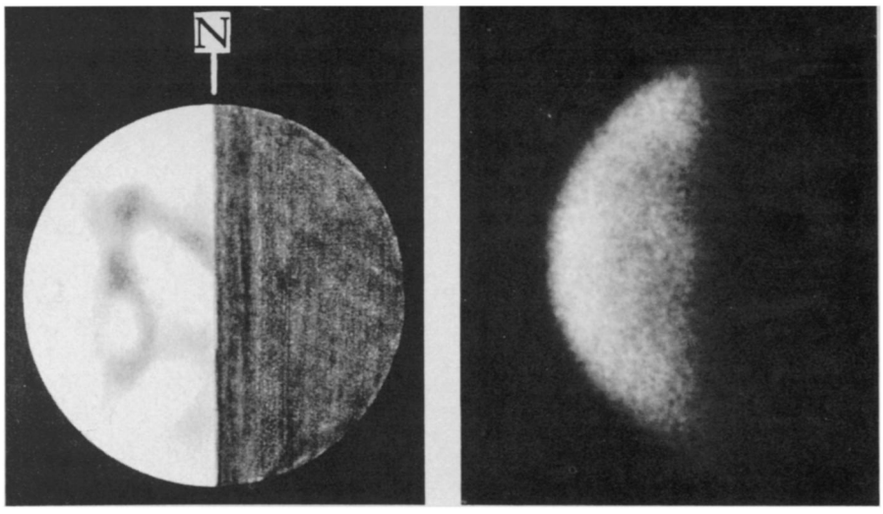
The most flagrant error, still found in many textbooks and encyclopedias and not corrected until 1965, was that Mercury presented one side or face to the sun at all times—that is, its rotational period was the same as its orbital period around the sun, 88 days. Sketches of the surface and polarization studies had seemed to indicate this. Furthermore, scientists reasoned, such rotation would be logical since Mercury is so close to the sun. It could be locked into its rotation as the moon is to the earth.

But radar studies, principally by G. H. Pettengill and R. B. Dyce, began to cast doubts on this theory. Ichtiaque Rasool, now of NASA headquarters, tells the story of going to France to discuss with Audouin Dollfus his sketches of Mercury's surface. These sketches had been used to support the 88-day rotation, and Dollfus had been the chief proponent of this theory. "We analyzed all the pictures, including those drawn by earlier astronomers in 1890 and 1920, and finally decided there could be solutions other than the 88-day rotation," recalls Rasool, "One solution could be 58.4 days ± 0.5," he says. Soon afterward, in 1965, the radar studies pinned the rotation down to 58.65 days—a rotation that would expose all sides of Mercury to the sun. This sent scientists back to their boards to recalculate surface temperatures and atmosphere and science fiction writers back to their typewriters to revise stories about the life confined to a narrow zone of twilight between sides of perpetual day and perpetual night.

The rotation, locked into 2:3 resonance, is unique in the solar system. Mercury makes three rotations about its axis for every two complete orbits around the sun. Scientists would like to know why the planet has this peculiar motion, how this relates to its elongated orbit, and how the nearness to the sun (perihelion is 29 million miles) has affected its shape. "The tidal forces of the sun would have the strongest effect on Mercury at perihelion," notes Rasool. If Mercury indeed has a bulge, Mariner 10 will be able to measure it precisely, he says.

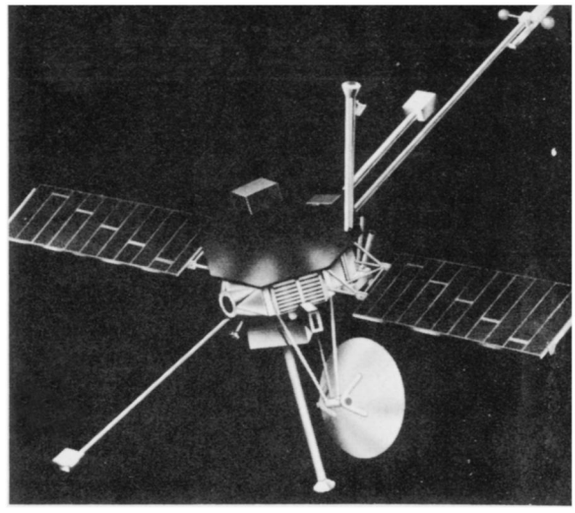
Geologists are anxious not only to determine the shape of Mercury, but also to see its surface. Shalhov Zohar and Richard Goldstein of the Jet Propulsion Laboratory in California have been trying to do just that with radar for several years. But it is difficult. "Everytime you double the distance of a planet, the radar echo power drops by a factor of 16," explains Goldstein of the difference between mapping Venus and Mercury. Mercury has the radar effectiveness of a dime at 10,000 miles. "It's a difficult target."

Nevertheless, Zohar and Goldstein



E. J. Reese/NMSU C. F. Knuckles/NMSU

Sketches from a photograph enhance the dark markings on Mercury's surface.



NASA

Mariner 10 will clarify the view.

have succeeded in getting some information. In 1970 the JPL group reported seeing rough features, such as craters, near Mercury's equator. Now Zohar is working on the latest data from a large area on the surface about 7 kilometers wide east to west and 60 kilometers long north to south. "We can see features a couple hundred meters high," says Goldstein.

Another way to analyze Mercury's surface is to study how it reflects light. Thomas B. McCord and John B. Adams of the Massachusetts Institute of Technology used this method to predict accurately the composition of lunar material at the Apollo 17 site. Earlier this year they reported that the reflection spectrum of Mercury indicates the surface is hot and covered with soil similar to that of an integrated (total) moon. The absorption bands are peculiar to titantium and iron glasses, says McCord. "There is at least as much glass as on the moon." They see pyroxene, a mineral common to basalts.

Although Mercury has often been compared with the moon, geologists think it's going to be very different. Scientists don't know whether the iron in Mercury is distributed throughout the body or concentrated in a core. But this content alone makes it an anomaly. "The bulk composition must be entirely different than the moon," says Strom. The scientists are anxious to see if this high density has modified internal processes within the planet and whether this is manifested on the surface.

In comparative planetology, Mercury fills a unique niche. Its size is between that of the earth and moon and the surface may be similar to the moon, but its escape velocity (the speed molecules have to attain to escape Mercury's atmosphere) is twice that of the moon. Its composition and nearness to the sun are probably a reflection of different evolutionary processes from those of the moon, Mars or earth.

How did Mercury end up with so much iron, if indeed that's what accounts for its density? One theory suggests Mercury started out like the earth, with the iron concentrated in the core. Then as a result of intense heating from the sun, the outer surface vaporized leaving just a thin mantle and a dense core. On the other hand, the density of the planets decreases as their distance from the sun increases. This may just mean that early in the solar system more iron was concentrated toward the sun (and Mercury got it), and the lighter elements were blown to the outer regions of the solar system.

Is the surface pristine, or has it been bombarded and modified by extensive melting such as occurred on the moon obscuring its original surface? There are proponents of both sides of the question. "We suspect the surface is not as bombarded as either the earth, moon or Mars," says Michael J. S. Belton of Kitt Peak National Observatory. "But we just don't know. We do know Mercury is going to be different. I hope the surface is a chaotic mess, the result of tectonic processes within the planet. But we'll just have to see."

Belton, along with Rasool and other atmospheric scientists, has been searching for gases in Mercury's atmosphere and trying to get a handle

MERCURY

Mean distance from sun	58 million km (36 million miles)
Minimum distance from sun	46 million km (29 million miles)
Maximum distance from sun	69 million km (43 million miles)
Eccentricity of orbit	0.2056
Inclination of orbit to ecliptic	7.004 degrees
Inclination of equator	7 degrees
Orbital period	87.969 earth days
Rotation period	58.646 earth days
Length of Mercury's day	176 earth days
Solar radiation flux	6.6 × that at earth
Mass (earth=1)	0.0553
Radius	2,435 ± 3 km (1,513 ± 2 miles)
Density	About 5.45 g/cm³ (?)
Escape velocity	4.2 km/sec (2.6 miles/sec)
Surface gravity (earth=1)	0.38
Magnetic field	Unknown, small if any
Visual albedo	7 percent (same as moon)
Midday surface temperature	343° C.
Nighttime surface temperature	About −170° C. to −120° C.
Surface pressure	Unknown, probably less than 1 millibar
Atmospheric constituents	Unknown, tenuous

on the surface pressure. There have been reports of hydrogen and carbon dioxide in the atmosphere. Oxygen may be there, as well as neon and argon. An ultraviolet spectrometer on board Mariner 10 will be used to search for this atmosphere, its structure and composition. A charged particle detector will measure particles over a wide range of energy in the upper atmosphere.

Recent estimates of atmospheric pressure at the surface range from 0.01 to 10 millibars (the latter is about one-hundredth of earth's surface pressure). Rasool and Belton think the pressure will be less than one millibar. But most expect to see more of an atmosphere on Mercury than on the moon because of Mercury's higher escape velocity, says Rasool.

The presence of an atmosphere is coupled closely with the presence of a magnetic field. "We really don't expect to find a large-scale global field," says Norman Ness of the Goddard Space Flight Center. However, says Ness, "Because of the high density and gravity, the weak atmosphere may interact with the solar wind to produce a class of phenomena never seen before."

With two radio transmitters on board Mariner 10, earth-based scientists will perform occultation experiments that should yield information about Mercury's atmosphere and ionosphere, as well as its mass and radius. A scanning electronic analyzer will be used to determine how the solar wind interacts with Mercury. An infrared radiometer will get measurements of both the sunside and nightside. Calculations place the temperature at local noon on the equator on the sunside at around 340 degrees C., and a range for the nightside temperatures between minus 175 degrees C. and minus 125 degrees C. But these calculations vary depending on what is assumed to be the surface thermal properties and constituents in the atmosphere.

Mariner 10 will give earthlings a good look at Mercury's surface. Two television cameras on board equipped with 1,500-millimeter Cassegrain telescopes will get a resolution of two miles of at least half the surface on the first pass. Many portions will be mapped with a resolution of 300 feet. Succeeding passes by Mercury will photograph more areas at 300 feet resolution. At encounter, each camera will take a picture every 42 seconds.

Cornell University's Carl Sagan, the articulate astronomer with a space-age imagination, describes an appropriate morning to conclude our imaginary astronaut's night on Mercury:

When morning comes at one point on Mercury, the sun rises very small, rising slower and slower, swelling to the zenith. At one degree past the zenith it stops. It then goes backward to the other side of the zenith and stops again. The sun then continues in the direction it was originally going toward the opposite horizon, shrinking as it sets.

Morning at a look-out point 90 degrees away is even more uncanny. A big swollen sun ponderously rises, looks at the surroundings and immediately sets again. Then, as if changing its mind, it rises again, going faster and faster, shrinking all the while to the zenith. It then goes toward the other horizon, slowing in speed and swelling in size as it sets. As though reluctant to leave, it then rises again to bid a fond farewell and finally sets. □

OFF *the* BEAT

Transition . . .

The preceding report on the planet Mercury is Everly Driscoll's last major article for SCIENCE NEWS. Starting this month, she will direct her writing talents toward an exclusively overseas audience in more than 100 countries—as a science and space writer for the United States Information Agency.

In the nearly three and a half years since she came to SCIENCE NEWS following eight years of teaching in Texas and six months of working in the office of astronaut Frank Borman in Houston, she has earned a reputation as one of the nation's outstanding space reporters. As scientists who have worked with her know, one of her major professional qualities as a reporter has been tenaciousness. During Apollo moon flights, she spent long hours day and night in the press room in Houston listening to air-to-ground commentary, often after most other reporters had closed down for the night. Such dedication made her the first reporter to learn of the explosion that crippled the Apollo 13 flight. She has been known to track sources by long-distance telephone to beachside vacation hideaways, and weekends and evenings never posed an obstacle to her news-gathering efforts. A second major quality—one equally appreciated by editors and scientists—has been her unwavering dedication to accuracy and balance. She spared no effort to verify the facts and judgments in her stories. She will be missed. We wish her the best of luck in her new duties.

Fortunately, we have to search only so far as one of our own staff members to find an experienced and talented successor: Jonathan Eberhart. In taking over the space-writing duties, he will be returning to familiar ground. He has been writing on space for SCIENCE NEWS since 1960. He was aerospace editor through all the formative years of Apollo, climaxing with his coverage of the historic Apollo 11 moon landing in July 1969 and the first Lunar Science Conference in Houston early the next year. Since his return to the staff in March this year he has written on topics ranging from earthquake prediction to archaeology, from Chinese clams to earth resources satellites. An enthusiast about space, science fiction, music, exotic food and a seemingly endless number of other matters, he brings a lively mind, an eclectic perspective and a gift for language to all his writing. I know you'll enjoy it.

—Kendrick Frazier

From sun, to satellite, to magazine, to art for floor

Every publication's staff likes to hear when its efforts prove useful to a reader, and ours is no exception. Recently we received a rewarding letter that describes what has to be one of the most unusual and creative applications ever made of magazine cover art. You may remember that the Jan. 27, 1973, issue of SCIENCE NEWS presented a full-color cover photograph of a computer-drawn color-coded map of the temperatures in the sun's corona based on data from the OSO 7 satellite. The photo showed a striking abstract pattern of blue, turquoise, violet, yellow, orange and red.

One subscriber, Mrs. John P. Magos of Wilmette, Ill., has been very busy since then. Obviously extremely skilled in hand-spinning and hand-weaving, she has woven an entire rya-type rug based on the design of the cover photo. She has sent us a snapshot of the rug. It is beautiful. "The background is of yarn handspun from the fleece of a black sheep," she writes. "The colors are of yarn handspun either from natural fleeces or fleece which has been dyed commercially for handspinners by Harrisville designs in New Hampshire . . . . It was great fun—and I am eagerly searching your magazine for new and exciting ideas for my future projects."

The January solar corona photo and the view of the Trifid nebula on the cover of our special astronomy issue in August were our first and second full-color covers of the year for SCIENCE NEWS, and only the third and fourth ones in our history (the other two were in 1970). This year's third color cover is tentatively scheduled for later this month.

—K.F.