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מכון לנוכחות ציבורית
INSTITUTE FOR PUBLIC PRESENCE
معهد للحضور الجماهيري

צורות נוף מדהימות נתגלו על אחד מירחי אוראנוס

– מאת כתב „רויטר" בפאסאדנה –

מדענים, שבדקו את התצלומים ששיגרה ספינת החלל „וויאג'ר" מכוכב הלכת אוראנוס, גילו באחד הירחים שלו צורות גיאולוגיות, הנמצאות גם בכוכבים אחרים של מערכת השמש.

מדובר בתצלומים שהגיעו מן הירח מירנדה, הסובב את כוכב הלכת אוראנוס. אוראנוס מרוחק כמעט שלושה מיליארד קילומטרים מכדור־הארץ, ואף על פי כן היו התצלומים באיכות מדהימה.

על מיראנדה נראו היטב מאות לועים של הרי־געש, ואדיות ועמקים, קניונים עמוקים ופסגות הרים. המדענים לא ציפו לגלות נוף כה מגוון על פניו של הירח הזה וקיבלו את הצילומים בקריאות התפעלות רמות. מאז התקרבה ספינת־החלל לאוראנוס, היא שיגרה לכדור־הארץ קרוב ל־6,000 תצלומים.

„אם אתה מעלה בדמיונך את כל הצורות הגיאולוגיות המוזרות ביותר של מערכת השמש ותחבר אותן יחדיו, תקבל משהו דומה למה שמופיע בתצלומים האלה שאני שם לפניכם", אמר לורנס סודרבלום, סגן־ראש הצוות העוקב אחר תצלומי „וויאג'ר".

הוא אמר במסיבת־עיתונאים, כי הירח מירנדה, שהוא הקרוב ביותר לכוכב הלכת אוראנוס מבין חמשת הירחים הידועים, כולל לפחות 10 פריטים טופוגראפיים שאין למצוא כמותם בשום מקום אחר.

הוא הוסיף, כי המבנה הטופוגראפי הזה מרמז על רעידות־אדמה, אולם לא ברור מה גרם להן.

כל חמשת הירחים חשוכים והבהירות הטובה של התמונות מוסברת במצלמות המצויינות שהורכבו בתוך „וויאג'ר". הקוטר של מירנדה הוא בערך 500 ק"מ, והמצלמות הראו בבהירות רבה פרטים קטנים אשר קוטרם אינו על 330 מטר.

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נתונים: פרופ' איליה לייבוביץ'

הנקודה הישראלית

תוכנית: פסל ראשון על המאדים

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יומן מסע

ר גולדין, אם כי
גילתה שכנים
אל הנשיא ביל
מימצאים. נמסר

המדעית ברחבי
יקה. אם בשלב
דורים כאן שוב
נה עד כה נושא
או כפי שהגדיר
אוניבסיטת סן
הגדולה ביותר
יקריות משונה,

ס נובל, מומחה
מאד, אבל איני
ה דוב אמר כי
על המאדים –
ר הארץ". הוא
י החיים הגיעו
למאדים דרך
ידות גבוה".

ל פרופ' איליה
במצפה־רמון,
שמה שהתרחש
פעמי, שיכול
, כי לפני שנה
לוש או ארבע
סביב לכל אחת
שלנו, וייתכן

ה פלישה של
ל ה„חיים" שם.

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תעודת זהות

• **גודלו של המאדים:** כמחצית מכדור הארץ. מסה: כעשירית.

• **אקלים:** טמפרטורה – בין מינוס 143 צלסיוס למינוס 27, סופות חול עזות שמהירותן עולה על 100 קמ"ש. אין אפשרות לקיום בני אדם ויצורים רומים.

• **אטמוספירה:** מאוד רלילה – 7 אלפיות האטמוספירה (לעומת אטמוספירה אחת על כדור הארץ). רוב האטמוספירה מורכבת מפחמן דו־חמצני, וכמעט שאין חמצן.

• **מים:** יש מים קפואים בקטבים, אבל רוב הכוכב צחיח לחלוטין. ייתכן שבגיאיות זרמו מים לפני מיליוני שנים.

• **פני הקרקע:** דומים לכדור הארץ. הצבע האדום בא מריכוז גבוה של תחמוצות ברזל. הנוף נקבע על ידי פגיעת מטאוריטים, פעילות געשית וסופות חול.

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יומן מסע

ממרינר ועד ויקינג

• 1964 – החללית האמריקנית „מרינר 4" חולפת ליד המאדים, מצלמת אותו, ומשדרת לכדור הארץ צילומים של פני הכוכב באיכות סבירה.

• 1969 – החלליות „מרינר 6" ו„מרינר 7" שולחות שתי סדרות נוספות של צילומים.

• 1971 – „מרינר 9" חללית ראשונה שלא רק חולפת ליד המאדים, אלא מקיפה אותו כדי לצלמו מכל עבר.

• יולי 1976 – „ויקינג 1" נוחתת על המאדים ונוטלת דגימות קרקע, בין היתר בניסיון לגלות סימני חיים.

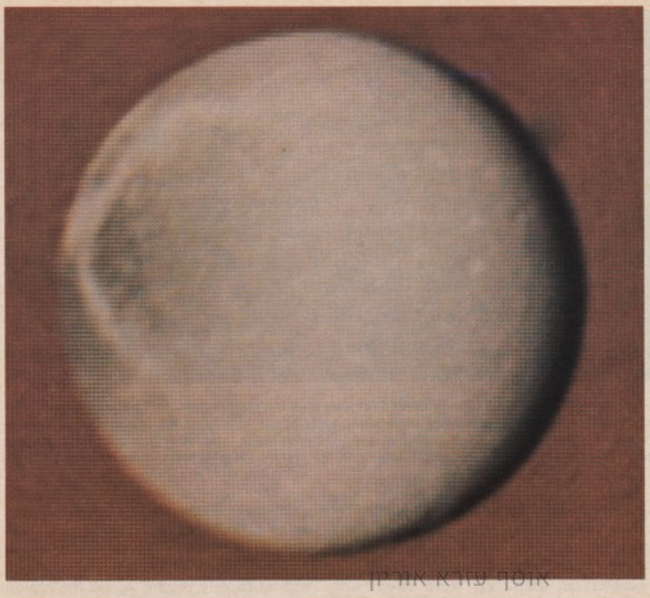
• אוגוסט 1976 – החללית „ויקינג 2" נוטלת דגימות דומות.

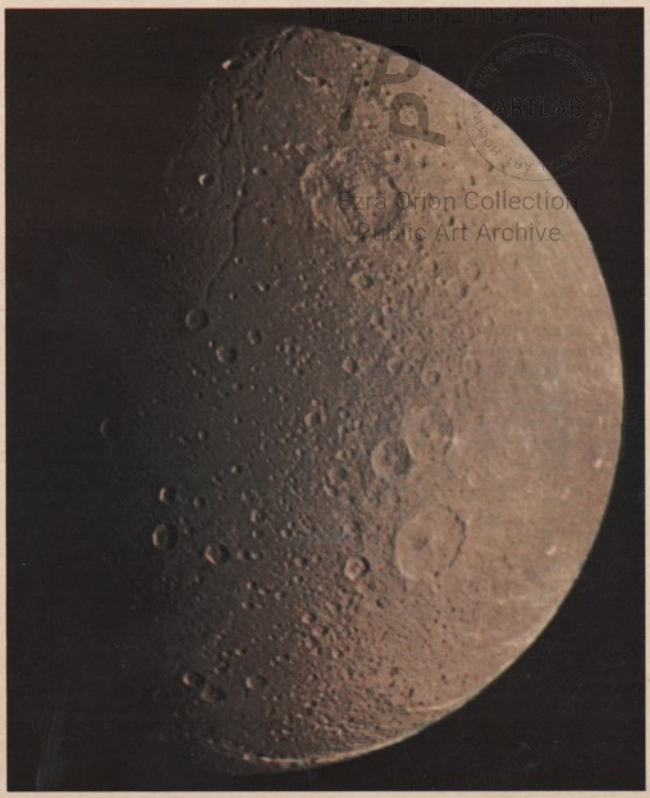
אריה אגוזי

an Article from

SCIENTIFIC AMERICAN

JANUARY, 1982 VOL. 246, NO. 1



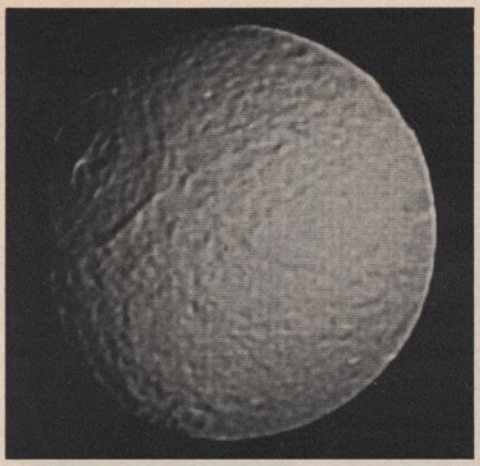


duced by collisions between large bodies. With Dione and Rhea it seems likely the small craters were made by the debris from bodies that collided within the Saturnian system. Presumably, therefore, certain regions of Dione and Rhea bear a record of primordial cratering; other regions were resurfaced by material from the interior that buried the oldest craters. The resurfaced regions were then pocked by a second bombardment. We shall refer to the bodies in the second bombardment as Population II.

A problem remains. The "highlands" bearing evidence of cratering by Population I and the plains bearing evidence of cratering by Population II show no correlation with the global pattern of albedo recorded by *Voyager 1* at a distance from Dione and Rhea. On Dione, for example, the leading hemisphere, which was uniformly bright and bland in the distant imagery, turns out at high resolution to have both highlands and plains. What, then, caused the global albedo pattern? Some calculations made by Eugene M. Shoemaker of the U.S. Geological Survey lead to estimates of the contributions that projectiles make today to the cratering of the Saturnian moons. For virtually any source of projectiles outside the Saturnian system the flux of impacts turns out to vary dramatically from the leading hemisphere to the trailing hemisphere of any given moon. For Dione, Shoemaker calculates a variation of 10 to one. For Rhea the variation is six to one. It makes no difference whether the projectiles are comets or asteroids or whether they have periodic orbits around the sun because the gravitational acceleration imparted to an arriving projectile by Saturn overwhelms the projectile's original trajectory.

Shoemaker further calculates that from the apex of Dione to the side of the body (with respect to the orbital motion of Dione around Saturn) the flux of arriving projectiles changes by a factor of

DIONE was photographed by *Voyager 1*. An image made on November 11, 1980 (*top*), shows the side of the moon that faces away from Saturn. The orange background is the top of Saturn's clouds, 377,000 kilometers from the moon. Dione is moving toward the right; the trailing hemisphere is at the left. The center of the trailing hemisphere shows bright wisps on a dark field. According to one hypothesis, a pattern of wisps once covered the entire surface of Dione. It was erased by the continual impact of small meteoroids over the history of the solar system, except at the center of the trailing hemisphere, where relatively few such projectiles arrive. An image made on November 12, 1980, at a range of 162,000 kilometers (*bottom*) shows what amounts to the prow of Dione. The apex of the leading hemisphere is at about the middle of the terminator along the left of the image. At the right is the side facing Saturn. The beginnings of several bright wisps in the trailing hemisphere are at the right limb of the moon.



LARGE IMPACT CRATER on Tethys is notably different from one on Mimas. The crater on Tethys (*left*) is more than 400 kilometers in diameter. It was photographed by *Voyager 2* at a range of 826,000 kilometers. When the crater was made, it must have been deep, and its rim and central peak must have been high. Today, however, the floor of the crater has rebounded to match the contour of the moon, and both the rim and the central peak have collapsed. Apparently Tethys once was warm enough to allow such rearrangement. In this image the apex of the leading hemisphere is near the center of the disk of the moon. The crater on Mimas (*right*) is 130 kilometers in diameter. It was photographed by *Voyager 1* at a range of 425,000 kilometers. It is the only large crater on Mimas. Its rim and its central peak are prominent. Apparently Mimas has long been cold. The crater's central peak lies at the apex of the leading hemisphere.

only two. From the side to the trailing end it changes by a factor of five. As a result the part of Dione least affected by the continuing impact of projectiles is only a small region at the trailing end of the moon.

With the aid of Shoemaker's calculations a history of Dione can be proposed. In this history the early life of Dione was dominated by the impact of large bodies most likely left over from the accretion of the solar system. Then parts of Dione were resurfaced. Meanwhile collisions near Saturn between the bodies left over from the accretion of the solar system yielded smaller bodies. Some of them took up orbits around Saturn much like Dione's. Their impacts with Dione cratered the newly formed plains moderately. At about this time fractures formed in the surface of Dione. The fractures were filled by bright extrusions from the interior.

It is likely that the entire surface of Dione then had the pattern now seen only at the center of the trailing hemisphere of the body. Over the past four billion years, however, Dione has rotated synchronously and its surface has been "gardened" by the impact of small meteoroids from outside the Saturnian system. The craters made by these bodies may be too small and too scattered to be identified in Voyager images. Still, the craters would rework the surface. In this way they erased the pattern of the surface in a region extending from the apex of the leading hemisphere well into the trailing hemisphere. This history accounts for the global pattern of albedo. The meteoroids arriving well into the history make up Population III.

Tethys

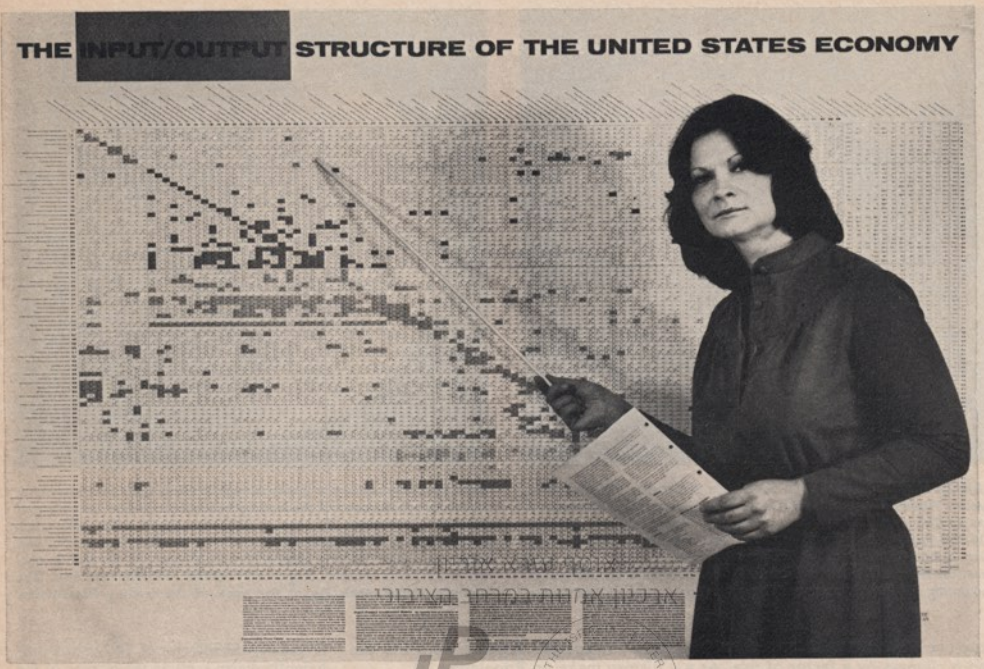
Tethys is the next moon inward from Dione; it travels in orbit around Saturn at a distance of 5 R_s. Its diameter is almost identical with that of Dione, but its density—1.2 grams per cubic centimeter—is lower. Moreover, its appearance is quite different. *Voyager 1* viewed Tethys only at low resolution. The images showed diffuse patches of small variation in albedo on a heavily cratered surface. The pattern did not resemble the more pronounced global pattern seen on Rhea and Dione. One of the best images showed a branching canyon spanning the distance between the north and south polar regions on the side of the moon facing Saturn. It was estimated the canyon was at least 1,000 kilometers long, 100 kilometers wide and several kilometers deep.

Nine months later *Voyager 2* approached Tethys. The images it transmitted to the earth revealed an enormous impact scar in the leading hemisphere. The rim of the scar has a diameter more than two-fifths the diameter of Tethys itself. As the spacecraft continued its approach the scar was photographed progressively closer to the visible edge of the moon. Soon an image showed it in profile. Here it could be seen that the floor of what must once have been a crater now matches the spherical shape of the body. Only a low rim and a subdued central peak remain. Evidently the interior of Tethys was sufficiently warm early in the history of the moon to allow the collapse of the raised topography. The same could be said of large craters on the icy Jovian moons Ganymede and Callisto.

Finally the north pole of Tethys and the side facing away from Saturn came into view. From this vantage it was apparent that the canyon found by *Voyager 1* extends over the north pole and down to the equator on the outward-facing hemisphere; thus the canyon traverses three-fourths of a great circle around the body. It could also be seen that parts of Tethys (like parts of Rhea and Dione) had been resurfaced. Smooth plains had developed in a small part of the leading hemisphere, and the resurfacing had buried some of the large craters already there.

A tentative explanation for the current appearance of Tethys begins with the surmise that at the time the large impact scar was made the interior of the body was much warmer and more mobile than it is today. Perhaps it was liquid. If Tethys had been cold and brittle when the scar formed, the impact that formed it might well have fragmented the moon. Moreover, the topography raised by the impact has clearly collapsed. The rim and the central peak of the impact scar persist. Hence it seems likely that much of the crust of Tethys in place at the time of the impact remains at the surface today. One can imagine, then, a simple history in which Tethys freezes from the crust down. If Tethys had first been liquid, the freezing would

THE INPUT/OUTPUT STRUCTURE OF THE UNITED STATES ECONOMY



WHAT MAKES THE U.S. ECONOMY TICK?

The editors of SCIENTIFIC AMERICAN have prepared a wall chart displaying for the 1980's the Input/Output Structure of the U.S. Economy based on the latest interindustry study from the U.S. Department of Commerce.

The SCIENTIFIC AMERICAN Input/Output wall chart does for economics what the table of elements does for chemistry. It answers at a glance questions about the linkage between the microeconomics of the firm and the macroeconomics of the system; about the web of technological interdependencies that tie industry to industry; about the industry-by-industry direct and indirect consequences of swings in public and private spending; about the impact of change in technology, and about any other topic you can think of. You are rewarded by surprise as well as by confirmation of your hunches. For teaching and practical and theoretical studies, here is a powerful, graphic tool.

In the familiar format of the SCIENTIFIC AMERICAN Input/Output wall charts for the 1960's and 1970's, the wall chart for the 1980's measures 65" × 52" and is printed in eight colors. Each of the nearly 10,000 cells in the 97-sector interindustry matrix shows (1) the interindustry commodity flow, (2) the direct input/output coefficient and (3) the "inverse" coefficient. Where the direct input/output coefficient exceeds .01, the cell is tinted in the color code of the industrial bloc from which the input comes. This device, combined with triangulation of the matrix, brings the structure of interindustry transactions into graphic visibility.

A supplementary table displays, industry by industry, the capital stock employed; the employment of managerial, technical-professional, white-collar and blue-collar personnel; the energy consumption by major categories of fuel, and environmental stress measured by tons of pollutants.

The editors of SCIENTIFIC AMERICAN are happy to acknowledge the collaboration, in the preparation of this wall chart, of Wassily Leontief, originator of input/output analysis—for which contribution to the intellectual apparatus of economics he received the 1973 Nobel prize—and director of the Institute for Economic Analysis at New York University

Packaged with the chart is an index showing the BEA and SIC code industries aggregated in each of the 97 sectors.

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have increased the volume of the object by about 10 percent and the surface area by about 7 percent. The estimated extent of the canyon on Tethys suggests that it forms 5 to 10 percent of the surface. The canyon may represent the stretching of Tethys' crust over the expanded, frozen interior.

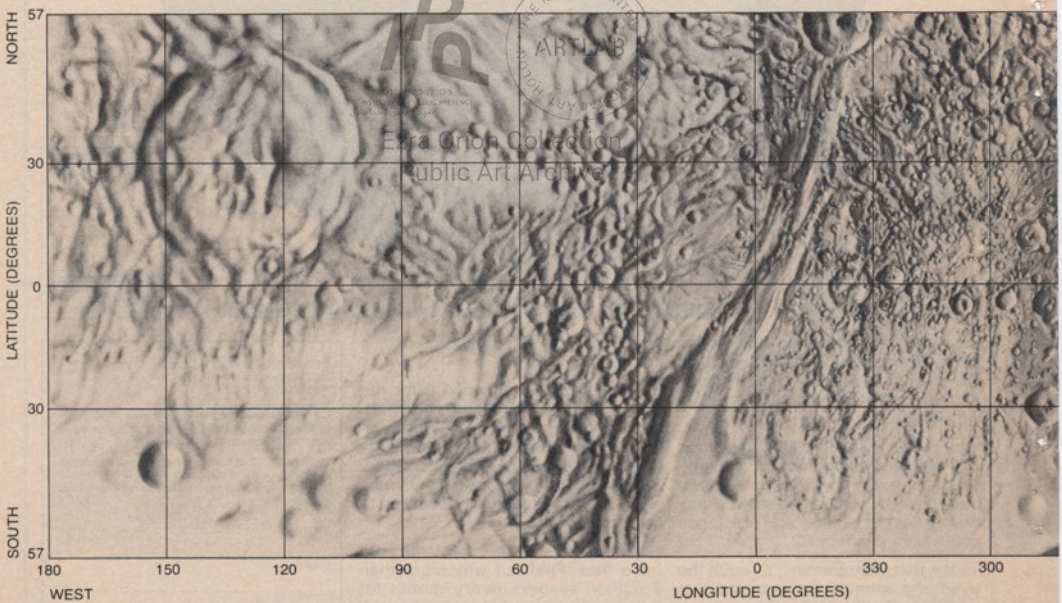
Mimas and Enceladus

The smallest of the nine moons whose presence around Saturn was known before the 20th century are Mimas and Enceladus. Each of them has only a thousandth the mass of a Galilean moon of Jupiter, a thousandth the mass of the earth's moon and a hundred-thousandth the mass of the earth. Their tininess is significant. Before the Voyager spacecraft began to explore the outer solar system the main source of heat in a planet or a moon was taken to be the decay of the radioactive atomic nuclei within it; hence it seemed that the history of a planet or a moon would be determined by the ratio of its volume to its surface area. The volume governs the quantity of radioactive nuclei and thus the generation of heat; the surface area governs the loss of heat and conversely the retention of it. The ratio of volume to surface area is determined by the size of the object: the ratio increases with the radius. One therefore supposes larger bodies are more likely to melt than small ones. Certainly the attribution of internal heat to radioactivity and the resulting correlation of heating with size explains the observations that volcanically the earth's moon is long dead, Mars is moderately active and the earth is quite active. It also suggests, however, that tiny moons such as Mimas and Enceladus should not have evolved substantially since the time they accreted.

The image of Mimas made by *Voyager 1* showed a surface that conforms to this prediction. The surface is uniform in albedo and is saturated with impact craters. It is a surface that has not been reworked by volcanism since the time of the Population I bombardment. In the leading hemisphere of Mimas there is an impact crater 130 kilometers in diameter, about a third the diameter of the little moon. One suspects other craters of that size or even larger should have been made in the course of the bombardment. Why are they not seen? If a cold, brittle Mimas had been blown apart by one such impact, the relative velocities at which the debris would fly apart would probably have been on the order of the velocity required for escape from Mimas' gravity. Such velocities are small compared with the orbital speed of Mimas, which is 30 kilometers per second. Hence the debris would have remained in a narrow band surrounding what had been the orbit of the moon. Gradually the debris would have reaccreted. The result would have been a cold mass of rubble consisting mostly of ice, but with a few percent of rock. (The density of Mimas is 1.2 grams per cubic centimeter.)

The statistics of the craters seen on Mimas suggest this may have happened. On Mimas today the largest crater is the one 130 kilometers in diameter. Then comes a gap in the sizes. The next-largest craters have diameters of only a few tens of kilometers. After that the abundance of craters increases exponentially as the diameter of the craters decreases. It is as if a large-scale impact had destroyed a parent body and the fragments had recombined. The present pattern of craters results, then, from impacts by the last of the fragments. The single largest crater represents a collision not energetic enough to have destroyed the body again; the other large craters made by Population I objects disappeared with the disruption of the parent body.

Voyager 1 provided only distant views of Enceladus, yet if the craters on Enceladus resembled those on Mimas, the im-



MAP OF TETHYS was prepared by the U.S. Geological Survey from images made by *Voyager 1* and *Voyager 2;* it is a Mercator projection, in which all latitudes and longitudes are made rectilinear. Zero degrees of longitude marks the center of the side of the moon that faces Saturn, 90 degrees marks the center of the leading hemisphere and 270 degrees marks the center of the trailing hemisphere. Two features dominate the topography. One of them is the collapsed impact crater shown in the photograph at the left on page 110. The central peak of the crater lies near 120 degrees longitude and 30 degrees north latitude. The other feature is a great canyon running from south to north between 30 and 330 degrees longitude. The canyon extends over the north pole of Tethys and then back toward the

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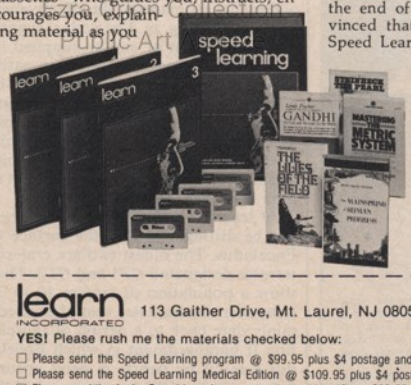

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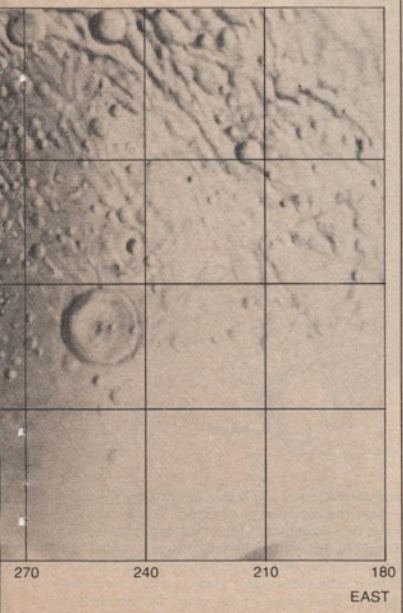
ages should have shown them. A crater as large as the one in the leading hemisphere of Mimas should certainly have been visible. Instead the images showed a surface that seemed to be smooth. More important, the surface of Enceladus was brighter than that of the neighboring moons Mimas and Tethys. This suggested that much of the surface of Enceladus may have been regenerated and is covered with very fresh ice.

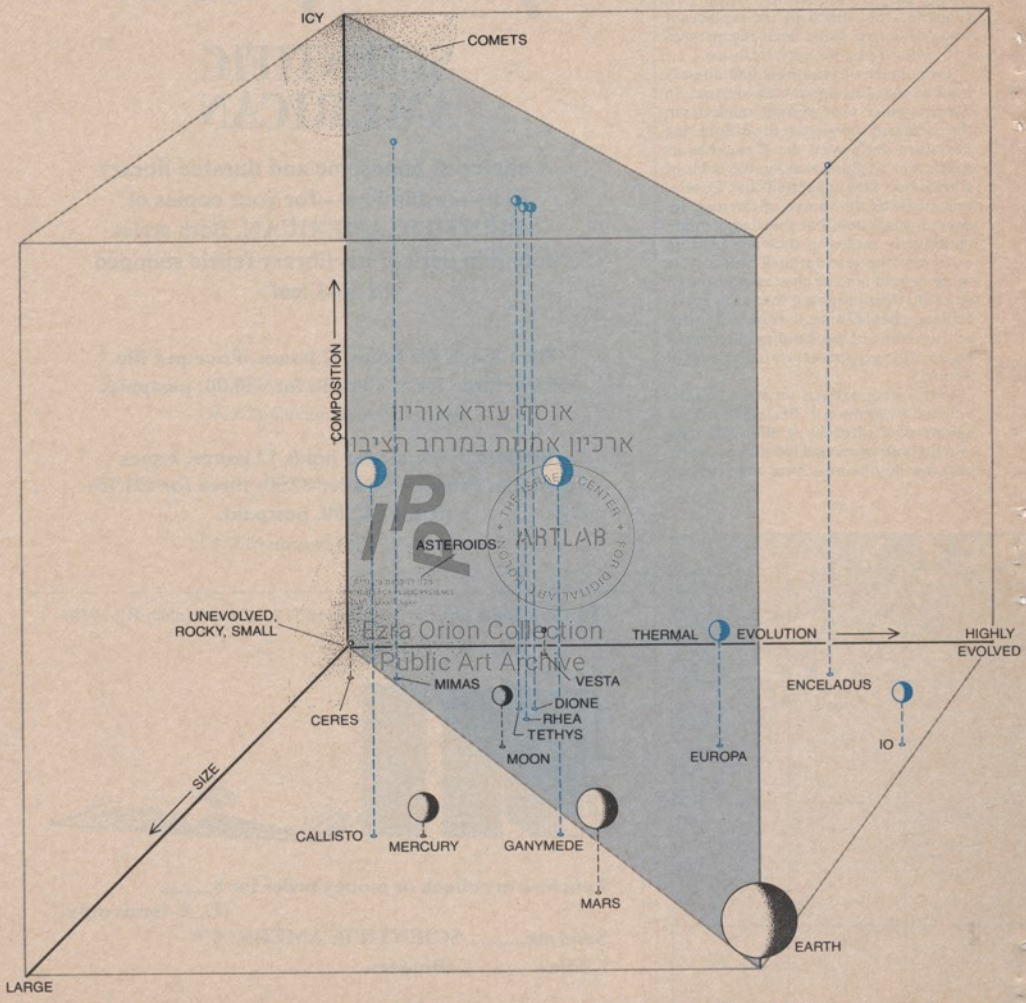
Two chains of reasoning had already implied that Enceladus was unusual. In the first place observations made from the earth had shown that the diffuse ring of Saturn designated the *E* ring has its maximum brightness along the orbit of Enceladus. This suggested that Enceladus might be the source of the ring. Indeed, it suggested that Enceladus might continually replenish the ring, because otherwise the gravitational field of the moon would tend to clear matter out of its orbit. (It is proposed that such gravitational shepherding is responsible for at least some of the banding discovered by the Voyager spacecraft in the rings of Saturn.)

In the second place, an argument developed by Stanton J. Peale of the University of California at Santa Barbara and his colleagues had led to the conclusion that Io, the innermost major moon



equator; its end is apparent at the upper right of the map. The canyon may represent the stretching of the crust of Tethys over an interior that expanded as it cooled and solidified into ice. The terrain on the map is shown as though it were all illuminated from the west.

of Jupiter, is heated substantially by tidal forces. Then Charles F. Yoder of the Jet Propulsion Laboratory of the California Institute of Technology proposed that a similar mechanism might act on Enceladus. Specifically, the orbital period of Enceladus is half that of Dione. This means that Enceladus and Dione align themselves with Saturn at fixed points in their orbits. The gravitational attraction of Dione for Enceladus acts repeatedly at these points, so that although the attraction is small, it makes the orbit of Enceladus stay slightly elliptical. In such an orbit Enceladus is forced to oscillate radially in Saturn's gravitational field, much as Io oscillates radially in Jupiter's. The internal friction that results from this oscillation might keep the interior of Enceladus warm and mobile. Gases and fluids es-



WIDE RANGE OF HISTORIES among planets and moons in the solar system is suggested when planets and moons with a visible solid surface are plotted in a cube whose axes represent their composition (from rocky bodies at the bottom of the cube to icy bodies at the top), their thermal evolution (from cold, unevolved bodies at the left to highly evolved, volcanic bodies at the right) and their size (from small bodies at the back to large bodies at the front). The black spheres are bodies whose position could be plotted before the Voyager spacecraft arrived in the outer solar system. In general these bodies (including Mercury, the earth, the earth's moon and Mars) are rocky. Moreover, the larger they are, the more they show signs of evolution and recent volcanic activity. In the illustration the rocky composition of the bodies means they lie near the bottom of the cube; the correlation between their size and their thermal evolution means they lie near a plane that passes through the cube diagonally from left to right. The correlation between size and evolution implies they derive their internal heat primarily from the decay of radioactive atomic nuclei. The colored spheres represent bodies that can be placed in the cube as a result of the study of their solid surface in Voyager images. Such bodies occupy a large part of the volume of the cube. They include Io and Enceladus, two small but highly evolved bodies that are thought to derive their heat from internal friction as each one moves in a slightly elliptical orbit around its parent planet. Io is a rocky moon, Enceladus is icy. Io, Europa, Ganymede and Callisto are the four major moons of Jupiter discovered by Galileo; Ceres and Vesta are bodies in the asteroid belt between the orbits of Mars and Jupiter.

caping from the interior might then keep the surface bright and remove the traces of craters. Allan F. Cook II of the Harvard College Observatory and the Smithsonian Astrophysical Observatory and Richard J. Terrile of the Jet Propulsion Laboratory have proposed that if Enceladus is geologically active, gases escaping from the interior of Enceladus and ice particles escaping from the surface might be the source of the *E* ring's material.

As *Voyager 2* flew close to Enceladus last August it transmitted back to the earth images that showed some craters after all. The craters, however, are sparser than the ones on Mimas, and some of them are in a state of collapse similar to that of old craters on Jupiter's moon Ganymede. The images of Enceladus made at the highest resolution show plains marked by a network of braided ridges but no craters whatever down to the limit of resolution. How old could such a surface be? Shoemaker's calculations suggest that the comets currently traversing the outer solar system should make craters on the plains that are visible at the resolution of the Voyager images in a few hundred million years. That amounts to about 10 percent of the age of the solar system. If other unseen bodies also hit Enceladus, the plains must be even younger.

It seems unlikely that Enceladus has been geologically active for 90 percent of its age but has now become inert; it is therefore highly likely that Enceladus is active today. The *E* ring and the extremely high albedo of the surface may result from this activity. It should be added that estimates of the effectiveness of tidal heating in Enceladus suggest that the amount of energy supplied by tidal forces is too small and too easily radiated into space for the interior to be a liquid if it consists of water. Perhaps, however, the interior includes methane clathrates or hydrates of ammonia. Such substances have a melting point about 100 degrees Celsius below that of pure water ice.

At least six different types of terrain can be distinguished on the surface of Enceladus. The oldest two are cratered terrains designated *CT*1 and *CT*2. They show a population of craters 10 to 30 kilometers in diameter that almost certainly date back to a period of Population II bombardment in which Enceladus was hit by debris in orbit around Saturn. On the *CT*1 terrains most of the craters have collapsed: their floors have rebounded, their rims have sunk and their central peaks are better described as gentle domes. On the *CT*2 terrains the craters are deep and bowl-shaped. The difference suggests that these different parts of Enceladus have had different thermal histories. The *CP*1 terrains are plains that show a relatively sparse distribution of craters between two and five kilometers in diameter. The craters lie on a rectilinear pattern of faults. Shoemaker's calculations suggest a range of ages. If the flux of recent projectiles has been minimal, the *CP*1 terrains may date back to nearly the time of the Population II bombardment more than four billion years ago. If the flux has been substantially greater, they may be a billion or even two billion years younger. In any event three still more recent terrains (*CP*2, *CP*3 and *RP*) also formed on Enceladus. They are revealed by the presence of corridors that cut through the older terrains so that parts of craters are obliterated.

The *RP* terrain includes the plains that show no craters. Its margin is marked by braided ridges. Two tentative hypotheses have been offered for the origin of the ridges. One explanation is that a system of faults was invaded by liquid water that froze. The expansion of the ice is what raised the topography. The other explanation is that a zone of solid-state convection slowly makes matter rise in the center of the plain and sink elsewhere, producing a roughly concentric pattern of wrinkles. Clearly Enceladus joins Io in showing that radioactivity does not always dominate the heating of bodies in the solar system. Enceladus has a hundred-thousandth the mass of the earth. It may nonetheless be just as active geologically.

Different Evolutions

The exploration of the Jovian and the Saturnian systems of moons by the Voyager spacecraft has yielded new insights into the evolution of the small bodies in the solar system. Imagine a three-dimensional chart whose axes are determined by measures of a body's size, composition and thermal evolution. Before the Voyager missions the only bodies that could have appeared in such a chart would have been the planets, moons and asteroids of the inner solar system. All of them fall into essentially the same class of objects of rocky composition, and their degree of thermal evolution is closely related to their size—a correlation suggesting that radioactive heating has dominated their history. In the wake of the Voyager missions a large part of the chart gains occupants, and the simple trend of evolution with size is destroyed.

Much remains to be discovered about the evolution of the moons in the solar system, but already it is apparent that nonradioactive sources of energy (for example tidal heating) are important for some of them. Moreover, it is apparent that an icy composition can allow vigorous geological activity even in very small moons. Further studies of moons will surely tell us much about both the conditions and processes in the incipient solar system and the ways planets evolve under a wide variety of circumstances.

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The Moons of Saturn

The 17 icy bodies that orbit the planet display a surprising range of geological evolution. Many of them show craters more than four billion years old, but one of them has terrain so new that no craters are seen

by Laurence A. Soderblom and Torrence V. Johnson

Before the spacecraft *Voyager 1* neared Jupiter in March, 1979, only five bodies in the solar system other than the earth had been observed in sufficient detail for their history to be surmised. In essence all of them (Mercury, the moon and Mars and its moons Phobos and Deimos) consist of rocky material. The encounter with Jupiter and its moons doubled the list. Moreover, it marked the first appearance on the list of planet-size moons composed mostly of ices.

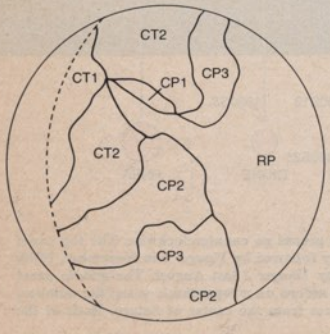
The encounters with the Saturn system doubled the list again. In November, 1980, *Voyager 1* flew past Titan, the largest moon of Saturn, at a distance of only 7,000 kilometers. It passed the smaller moons Mimas, Dione and Rhea at greater distances but nonetheless transmitted high-resolution images of each back to the earth. The trajectory of *Voyager 2* had already been devised to bring the spacecraft closer than *Voyager 1* had come to the moons Iapetus, Hyperion and Phoebe; in addition it would come very close to Tethys and Enceladus. In the months before the arrival of *Voyager 2* near Saturn last August the sequence of observations planned for the spacecraft was altered to provide for observations of several newly discovered moons, three of which were found by *Voyager 1*. In spite of a temporary jam in the mechanism that points the cameras on *Voyager 2*, the mission was successful. In a few short months, therefore, the moons of Saturn have been transformed. Before November, 1980, the ones that were known were no more than dots of light in a telescope. Now they form an array amounting to 17 new worlds.

General Properties

Several generalizations can be made about the moons of Saturn. In the first place only one of them has any appreciable atmosphere. It is Titan, whose atmosphere is opaque to visible light. Since no one has seen the surface of Titan, we have little direct information about its geological evolution. Second, it can be calculated that all but the three outermost moons of Saturn should certainly be in synchronous rotation: they should keep the same face turned toward the planet, just as the moon keeps the same face turned toward the earth. In each such case a planet's gravitation raises a tidal bulge on a moon. Then the gravitational attraction between the bulge and the planet acts as a torque that slows the moon's rotation until the rotation is synchronous. The Voyager images suggest that all but one or possibly two of the moons of Saturn really do rotate synchronously. The definite exception is Phoebe, the outermost moon, which is too small and too far from the planet to lose its spin to tidal forces. It rotates once every nine hours, whereas its orbital period is 13,211 hours, or 1.5 years. The possible exception is Hyperion, the third-outermost moon. The images made of Hyperion by *Voyager 2* cover only a short arc of the orbit of the moon and leave it uncertain whether Hyperion rotates synchronously or not.

Finally, all but two of the moons of Saturn form a regular system of satellites. That is, their orbits are nearly circular and lie in the equatorial plane of the planet. The two exceptions are Iapetus, the second-outermost moon, whose orbit is inclined 14.7 degrees with respect to the equatorial plane, and Phoebe, the outermost, whose orbit is inclined 150 degrees. (In addition the orbital motion of Phoebe around Saturn is in a direction opposite to that of all the other moons.) Three regular systems of satellites are known in the solar system; they consist of the inner moons of Jupiter, the inner moons of Saturn and the five known moons of Uranus. It is probably no coincidence that those planets all have rings. Rings and a regular system of satellites may form naturally as a by-product of the accretion of a giant planet. In any case each regular system of satellites is thought to have formed from the gas, ice and dust around each incipient giant planet, much as (on a larger scale) the planets formed around the sun.

Observations made with telescopes before the Voyager spacecraft arrived showed that among the moons of Saturn only Titan is as large as the four moons of Jupiter discovered by Galileo; the others are smaller than the earth's moon. The Voyager images show that the moons span a range of sizes from the size of asteroids to that of Mercury. The masses of Saturn's moons remain difficult to specify. An analysis of the mutual gravitational effects the moons have on one another has yielded values for some of the masses, and the tracking of gravitational perturbations in the trajectory of the Voyager spacecraft as they



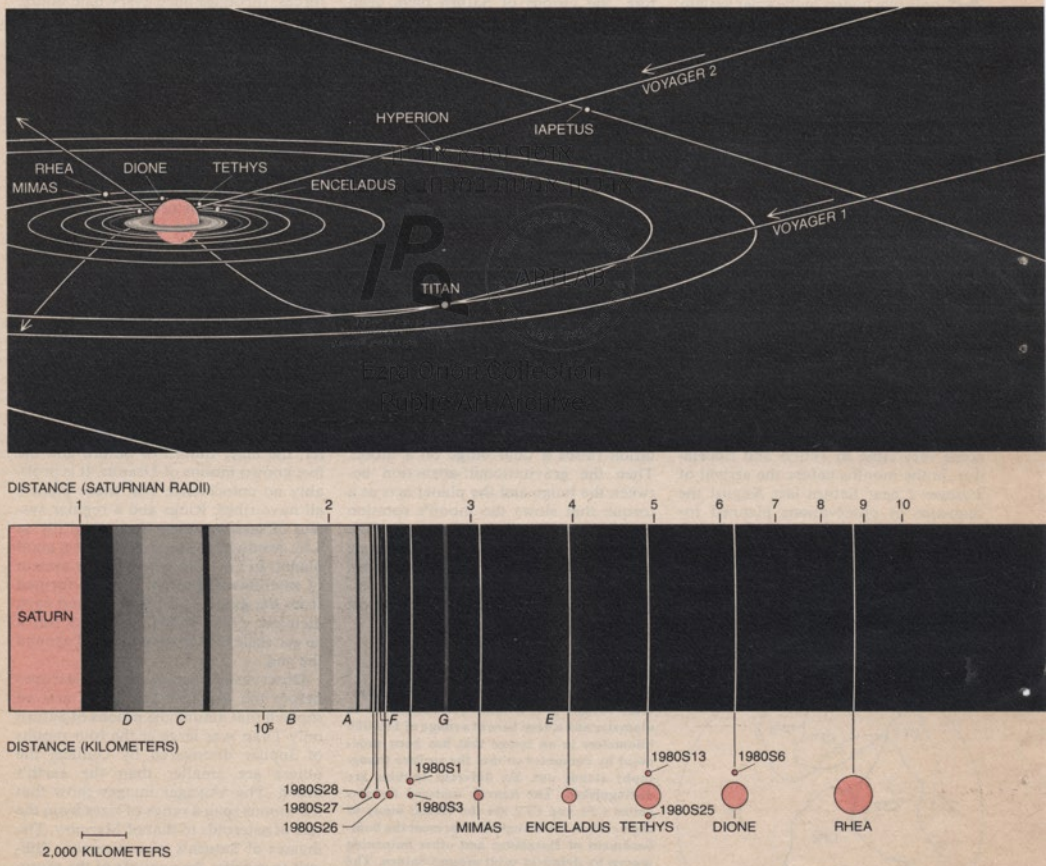
SATURNIAN MOON ENCELADUS was photographed last August 25 by the spacecraft *Voyager 2*. It is some 500 kilometers in diameter and is seen here at a range of 119,000 kilometers in an image that has been processed by computer so that the surface topography stands out. Six different terrains are distinguished. The heavily cratered terrains called *CT1* and *CT2* are the oldest; many of their craters are thought to represent the bombardment of Enceladus and other Saturnian moons by debris in orbit around Saturn. The debris was left over from the accretion of the planet, its moons and its rings. The cratered plains *CP1*, *CP2* and *CP3* are intermediate in age. The ridged plain *RP* is the youngest; on one hypothesis it lacks visible craters because it consists of upwelling fresh material.

passed among the moons yields new values and refinements of some of the earlier ones. It seems clear from the various measurements that the moons of Saturn all have densities of less than two grams per cubic centimeter. In fact, several have densities of less than 1.5 grams per cubic centimeter. Such values suggest that the moons are composed mostly of ice. For most of Saturn's moons a composition of 30 to 40 percent rock and 60 to 70 percent ice by weight would match the calculated density. Only Titan is large enough for its gravitational self-compression to affect its density appreciably. When this self-compression is taken into account, the density estimated for Titan—1.9 grams per cubic centimeter—becomes compatible with a mixture of half rock and half ice.

In one sense the calculated densities are curious. Among the planets of the solar system one finds a trend toward greater density with decreasing distance from the sun, and among the moons of Jupiter one finds a trend toward greater density with decreasing distance from the planet. Such trends are attributed to the influence of the heat from the central body on the temperature of the gas and dust that surrounded it at the time its satellites formed. In the case of Jupiter it appears that ice was unstable in any large quantities at radial distances from the planet less than the distance of the orbit now followed by Ganymede.

In spite of the uncertainties in the measurements no similar trend of density is evident among the moons of Saturn. Instead the current determinations of the values of the densities are consistent with a composition of rock and ice that is similar in all Saturn's moons except for more or less random variations in the exact proportions. On the other hand, the densities of Saturn's moons in general are less than those of Jupiter's. This suggests a greater proportion of ice. The relative lack of rocky material is explained by models of Saturn's history developed by James B. Pollack and his colleagues at the Ames Research Center of the National Aeronautics and Space Administration. The models suggest that rocky material near Saturn was swept into the incipient planet as it contracted before its moons began to form some 4.5 billion years ago.

In any event the surfaces of the moons of Saturn suggest the presence of ice.



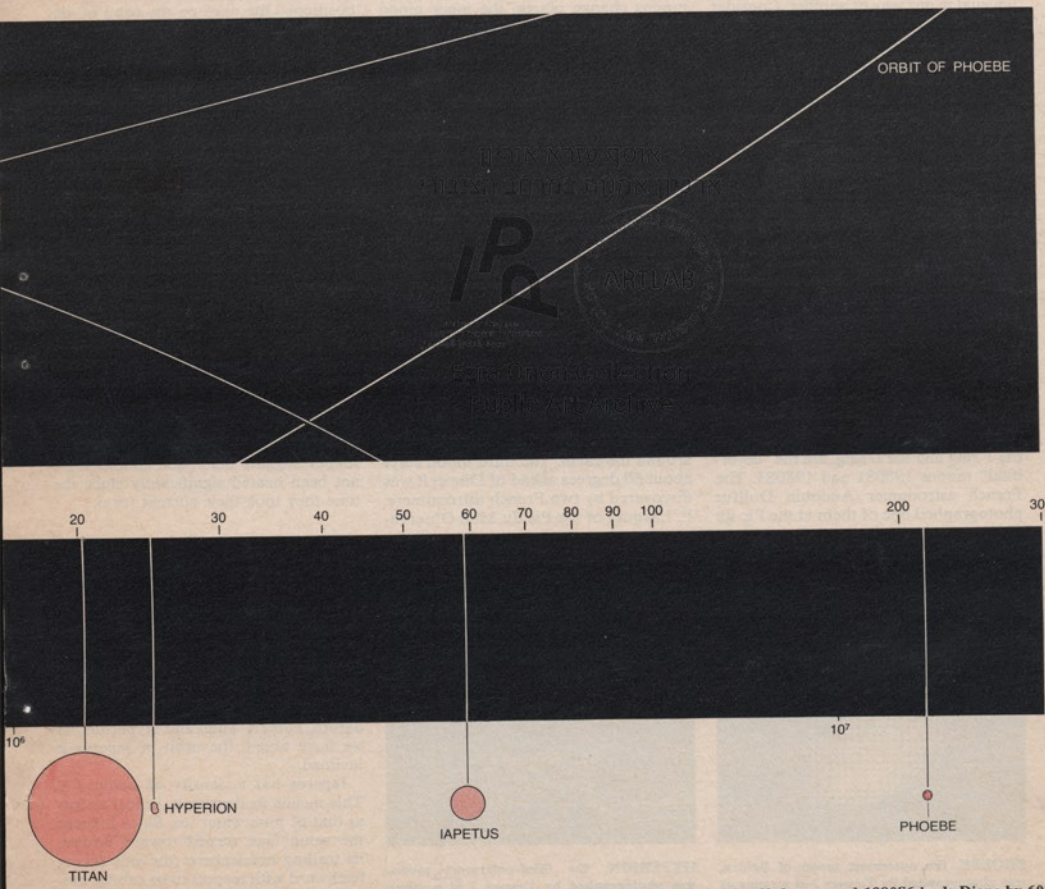
KNOWN MOONS OF SATURN are 17 in number. The top panel shows their orbits. All but two of them lie in the equatorial plane of the planet, which is also the plane of the planet's rings. The exceptions are Iapetus (with an orbit inclined by 14.7 degrees) and Phoebe (with one inclined by 150 degrees). Phoebe's rotation about Saturn is clockwise; all the other moons go counterclockwise. The top panel also shows the trajectory followed by *Voyager 1* in November, 1980, and the one followed by *Voyager 2* last August. The middle panel shows the orbits of the moons on a logarithmic scale; the numbers on the scale are distances from the center of Saturn. Each of the

Spectra of the solar radiation reflected by the moons in the near infrared show its absorption at wavelengths characteristic of water frost. Moreover, measurements made by the Voyager spacecraft show that most of the moons reflect between 60 and 90 percent of the radiation that hits them. With an albedo, or reflectance, of nearly 100 percent, Enceladus is the most reflective body in the solar system. If it were at the same distance from the sun as the earth's moon, it would be about five times as bright. Water ice is highly reflective.

The ubiquity of ice in the outer solar system was not entirely unexpected. For one thing, the vapor pressure of water ice (that is, the tendency of the ice to sublimate and lose vapor to space) depends strongly on temperature. Hence at distances from the sun less than the distance of the asteroid belt between the orbits of Mars and Jupiter an unprotected mass of ice will evaporate in a time quite short compared with the age of the solar system. At greater distances a mass of ice will be stable for billions of years. In addition most models of how the solar system formed predict that water should be a major constituent of a body that accreted at low temperatures.

Specifically, if a gas whose composition is much like that of the sun is cooled under the conditions of temperature and pressure thought to have prevailed in the early solar system, some of the oxygen in the gas will combine with silicon to form silicate rock at relatively high temperatures. When the elemental silicon is exhausted, however, a substantial amount of oxygen will remain. As the temperature continues to decrease it will combine with hydrogen, the element most abundant in the gas. Thus water will form. It emerges from such models that a moon condensing at low temperatures should have much the same proportions of rock and ice as those inferred for Jupiter's moons and Saturn's moons from the estimates of their densities.

One might suppose an icy moon would be no more interesting geologically than a cratered ice cube. Ice, however, has a melting point far lower than that of rock, so that relatively little is needed to melt the interior of an icy moon in the outer solar system. On this basis it was suspected even before the Voyager missions that such moons



moons discovered recently turns out to have a dynamical vagary. The moon 1980S28 lies near the outer edge of the *A* ring; 1980S27 and 1980S26 bracket the *F* ring, and 1980S1 and 1980S3 have orbits that differ by less than the sum of the diameters of the moons (hence they are "co-orbital"). Finally, 1980S13 leads Tethys by 60 degrees, 1980S25 trails Tethys by 60 degrees and 1980S6 leads Dione by 60 degrees. Each of the three occupies a position of stability studied by Joseph Louis Lagrange in the 18th century and today called a Lagrange point. They are the first known Lagrangian moons. At the bottom of the illustration all the moons of Saturn are shown to scale.

might show signs of geological activity. It was also proposed that the moons of the outer solar system might incorporate substances such as ammonia hydrates and the compounds of methane and water known as clathrates. The interior of a moon incorporating such material would melt even more readily than a moon consisting of rock and water ice alone. The results of the Voyager missions surpass the speculations. Hyperion, Mimas and Enceladus, for example, are much the same size, but they display a range of geological evolution far broader than one would have thought was likely.

The New Satellites

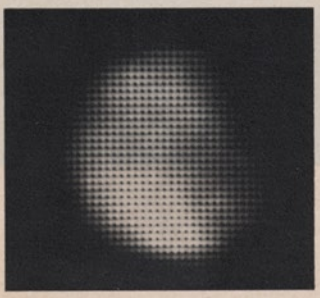
The moons of Saturn discovered in the past decade have dynamics that are unusual in one way or another. Consider 1980S28, the innermost moon in the set and also the innermost known moon of Saturn. It was discovered by *Voyager 1* just beyond the outer edge of Saturn's *A* ring. 1980S28 is an elongated body whose diameter is about 40 kilometers. One hypothesis suggests that its gravitational field does much to sculpture the sharp outer edge of the ring. Somewhat farther out from Saturn are the pair of small moons 1980S27 and 1980S26. They too were discovered by *Voyager 1*, although it can now be recognized that at least one of them may have affected the counts of charged particles made by the *Pioneer 11* spacecraft near Saturn in September, 1979. Between their orbits lies the multistrand *F* ring. The gravitational fields of the moons may well confine the ring. For that reason they are called the shepherd moons.

About 10,000 kilometers beyond the *F* ring, or roughly halfway between the *F* ring and the *G* ring, are the "co-orbital" moons 1980S1 and 1980S3. The French astronomer Audouin Dollfus photographed one of them at the Pic du Midi Observatory in 1966. Today it is difficult to say which one it was. In 1978 John W. Fountain and Stephen M. Larson of the University of Arizona determined that there were two moons. Then in 1979 *Pioneer 11* made an image of one of them. The Voyager spacecraft made images of both. The mean orbital radii of 1980S1 and 1980S3 differ by less than the sum of their diameters. Hence their orbital velocities are similar but not quite identical: the inner moon slowly overtakes the outer one. As they approach each other the gravitational attraction between them alters their angular momentum. The inner moon gains momentum; it moves into a larger orbit, where its orbital speed is reduced. The outer moon loses momentum; it moves into a smaller orbit, where its orbital speed is increased. In short, the two moons change places; the inner moon becomes the outer one and begins to fall behind. About once every four years the celestial dance is repeated and the two change places again.

Three other new moons of Saturn were found by earth-based telescopes in 1979 and 1980, a time when Saturn's rings were edge on as they are seen from the earth. This orientation greatly reduces the effect of scattered light from the rings when Saturn is viewed in a telescope and allows the detection of faint bodies close to the planet. Two of the three new moons share their orbit with Tethys. One of them maintains a position about 60 degrees ahead of Tethys; it was discovered by a group led by Bradford A. Smith of the University of Arizona. The other stays about 60 degrees behind Tethys; it was discovered with the aid of a prototype of a planetary camera system designed for the telescope that the U.S. plans to put in orbit around the earth. The third moon stays about 60 degrees ahead of Dione; it was discovered by two French astronomers: P. Lacques of the Pic du Midi Observatory and J. Lecacheux of the Paris Observatory.

Each of the positions occupied by these moons is a point of dynamical stability of the kind first studied by the French mathematician Joseph Louis Lagrange and today called a Lagrange point. In 1772 Lagrange noted that in a system consisting of one body in orbit around another (say the moon around the earth) there are five positions at which a third body can lie undisturbed. Three of the positions are unstable: a body at any one of them is readily driven from it by the influence of gravitational forces other than those exerted by the two bodies that set up the system. The three positions lie (1) inside the orbit of the satellite, (2) outside the orbit and (3) at the point in the orbit opposite the satellite itself. The remaining two positions—the ones on the orbit 60 degrees ahead of the satellite and 60 degrees behind—are quite stable: a body that occupies either one of them will merely drift back and forth along its orbit under the influence of perturbing forces. It has long been known that the groups of asteroids called the Trojans occupy the two Lagrange points 60 degrees from Jupiter along the orbit of the planet around the sun. The three bodies at Lagrange points near Saturn are the first known Lagrangian moons.

In contrast to their dynamical vagaries the newly discovered moons have much the same appearance. Each is rather small, and almost all of them are quite irregular in shape. The irregularity tells much. It suggests that each moon arose from the fragmentation of a larger body. And since a small, cold, icy moon is strong enough to keep itself from being pulled into a sphere by its gravitational self-attraction, the irregular shapes suggest that these moons have not been heated significantly since the time they took their current form.



PHOEBE, the outermost moon of Saturn, was photographed by *Voyager 2* at a range of 2.2 million kilometers. Its curious orbit and its low reflectivity (about 5 percent) suggest that it formed elsewhere in the solar system and then was captured by Saturn's gravity. Phoebe is about 200 kilometers in diameter.

HYPERION, the third-outermost moon, was photographed by *Voyager 2* at a range of 500,000 kilometers. It is an irregular body about 400 kilometers long and 220 kilometers wide. It is four to six times brighter than Phoebe. The concavities along the margin of this image of Hyperion are probably craters.

Iapetus

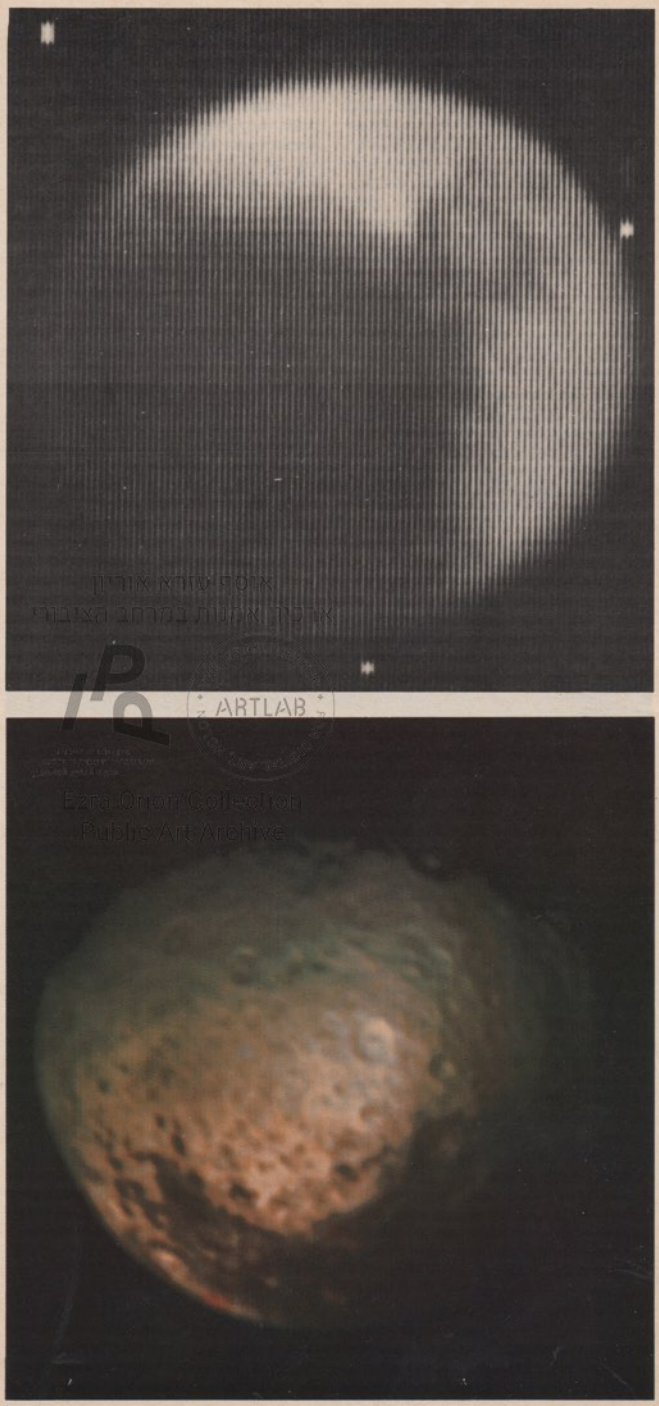
Iapetus and Rhea are the second-largest of Saturn's moons; they have a nearly identical diameter of about 1,500 kilometers. They move in quite different orbits. The orbit of Iapetus lies about 60 Saturnian radii (R_s) from the center of Saturn, that of Rhea about 9 R_s. They bracket the orbits of two other moons of Saturn, namely Titan and Hyperion. As we have noted, the orbit of Iapetus is inclined.

Iapetus has a density of about 1.1. This means its density is almost as low as that of pure water ice. Since it keeps the same face turned toward Saturn, its trailing hemisphere (the side facing backward with respect to its orbital motion) is always the same part of the surface. The trailing hemisphere is bright. In the visible region of the electromagnetic spectrum its albedo is almost 50 percent. In contrast the leading hemi-

sphere is extremely dark: its albedo is only 3 to 5 percent. This difference was noted in the 17th century by Jean Dominique Cassini, the discoverer of Iapetus, who found he could see the body on one side of Saturn but not the other. Among the few materials whose albedo is only a few percent are lampblack and the primitive meteorites called carbonaceous chondrites.

The peculiar pattern of darkness and brightness on Iapetus has suggested that dark material falling from space coats what amounts to the prow of the moon. In 1974 it was further suggested by Steven Soter of Cornell University that the source of the material is Phoebe. Phoebe had long been taken to be a moon of low albedo; observations made with earth-based telescopes show that its color is similar to that of many dark asteroids. The idea, then, is that dark matter is kicked off Phoebe by the impact of micrometeoroids. Then the particles of the matter come under the influence of what is called the Poynting-Robertson effect. Specifically, electromagnetic radiation leaves each particle because the particle reflects some of the radiation incident on it and because the particle absorbs some radiation and reemits it later. In either case the radiation leaving the particle in the direction of the particle's orbital motion around Saturn undergoes a Doppler shift that gives it a higher frequency (and thus more energy and momentum) than that of the radiation leaving in the opposite direction. The net result is that the particle loses orbital angular momentum and slowly spirals inward. As it falls (the argument concludes) it is swept up by Iapetus.

The images of Phoebe made by *Voyager 2* show some detail of Phoebe's sur-



IAPETUS was photographed by *Voyager 1* at a range of 3.2 million kilometers and nine months later by *Voyager 2* at a range of 1.1 million kilometers. The image made by *Voyager 1* (*top*) shows the side of the moon that always faces Saturn. (Iapetus and most other Saturnian moons keep the same face turned toward Saturn, just as the earth's moon keeps the same face turned toward the earth.) Iapetus is moving toward the left; the leading hemisphere of Iapetus (the hemisphere facing in the direction of the orbital motion of the moon) is dark. A ring of dark material extends, however, into the bright trailing hemisphere. The image made by *Voyager 2* (*bottom*) shows the side of the moon that always faces away from Saturn. The north pole of the moon coincides roughly with the large crater astride the border between day and night on Iapetus (the terminator), which crosses the top of the image. The dark leading hemisphere is at the right. An equatorial band of darkness extends into the trailing hemisphere. The sharp and complex boundary between bright and dark regions on Iapetus militates against the proposal that dark matter fell from space onto the leading part of the moon. It suggests instead that the dark matter is an extrusion from within Iapetus.

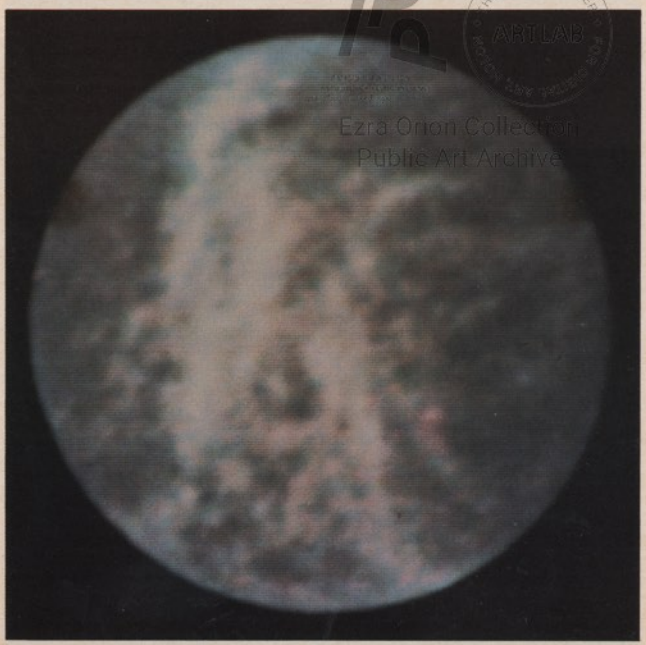
face. Phoebe emerges as being roughly spherical and having an albedo of only about 5 percent. In both of these attributes (and in its inclined, retrograde orbit) it proves to be quite different from the co-orbitals, the ring shepherds and the Lagrangian moons of Saturn. Phoebe may indeed be a captured dark asteroid, unchanged since it accreted early in the history of the solar system. Perhaps it is a primordial body that was ejected from the inner solar system by the gravitational field of the growing planet Jupiter and took up an orbit around Saturn.

In themselves the Voyager images of Phoebe cannot make it plain whether Phoebe dusted the dark leading hemisphere of Iapetus; the idea is still being debated. One test of the idea involves Hyperion, the next moon inward from Iapetus. The test rests on the assumption that Hyperion should have been dusted by material kicked off Phoebe that Iapetus failed to sweep up. The images made by *Voyager 2* show Hyperion to be a remarkable little moon. It is nearly the size of Mimas, a spherical moon with a radius of about 200 kilometers, and yet it is markedly elongated: its short axes are only about three-fifths the length of its longest axis. Hyperion is one of the largest bodies in the solar system that has an irregular shape. (The asteroid Hector is one of the very few other such objects.) An analysis of the Voyager images indicates that Hyperion is somewhat darker than most of the moons of Saturn: its albedo is 20 to 30 percent. This finding is consistent with a dusting by matter from Phoebe. Hyperion appears, however, to lack a dark leading hemisphere. The problem with searching for one is that it is not yet established whether Hyperion rotates synchronously.

An answer to the question of whether Phoebe dusted Iapetus therefore awaits in part the determination of the rotation rate of Hyperion from observations made with ground-based telescopes. Meanwhile the findings of Dale P. Cruikshank and his associates at the University of Hawaii at Manoa may have got the idea into trouble on other grounds. Cruikshank's group has found from telescopic observations that the color of Phoebe and the color of the dark leading hemisphere of Iapetus are different. The dark regions on Iapetus are much redder than Phoebe throughout the visible and the near-infrared region of the spectrum. This makes it difficult to favor a scheme in which material from Phoebe simply coats the dark part of Iapetus without having undergone some kind of change.

The images of Iapetus made by the Voyager spacecraft also tend to subvert the hypothesis that it was dusted by matter from Phoebe. *Voyager 1*'s best image of Iapetus was made at a range of 2.5 million kilometers. The image showed only those features on Iapetus that are more than 50 kilometers across. Even so, a clue to the history of the body emerged. A ring of dark material about 100 kilometers in diameter was found to straddle the border between the hemispheres. It strongly resembles the rings in craters along the margin of large volcanic flood plains on the moon and Mars. Such rings formed there when dark volcanic melts flowed into impact craters and filled each one around its central peak. Perhaps the dark ring on Iapetus formed by a similar process when fluid extruded from the interior of the body darkened half of it. Clearly it is unlikely that a feature with such a peculiar geometry as that of a dark ring could have been formed by matter falling from space.

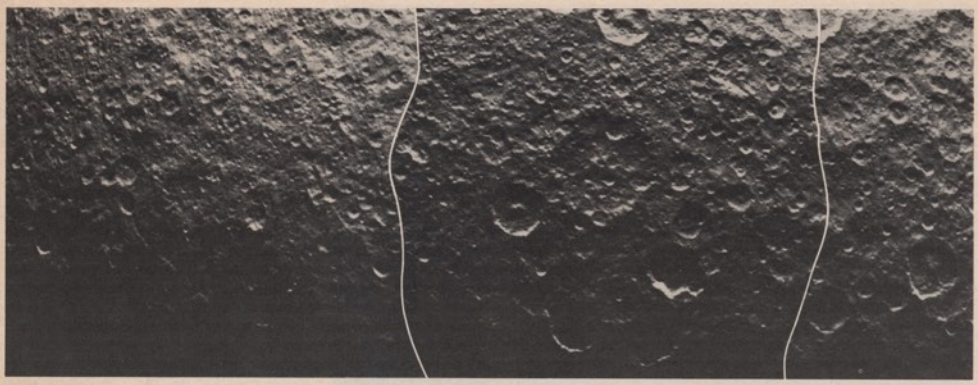
Voyager 2 made a series of images of Iapetus at a resolution three times greater than that of the images made by *Voyager 1*. The single best image is of the north polar region, mostly in the bright trailing hemisphere. It shows that the trailing hemisphere is heavily cratered. Many of the craters have a dark floor. Such floors resemble the dark floors of craters on the highlands of the earth's moon, which are thought to have formed when volcanic material flowed out over them. Taken together, the dark-floored craters in the trailing hemisphere and the sharp definition and complexity of the boundary between dark and bright terrain imply a history of eruptions from the interior of Iapetus. That is not to say the erupting material resembles any ordinary lava. One can speculate that it is a fluidized slurry of a mixture including ammonia, ice and something dark. The low albedo of the material suggests that whatever its origin, the dark stuff is rich in organic substances such as are found in primitive meteorites.



RHEA was photographed by *Voyager 1* at a range of 1.7 million kilometers. Here the image of the moon is shown in false color. The trailing hemisphere (seen here) is marked by bright wisps that do not seem to follow a pattern laid down by craters. The leading hemisphere is bland.

Rhea

The distant views of Rhea transmitted to the earth by *Voyager 1* as the spacecraft approached the moon showed a bright, bland leading hemisphere marked only by what appears to be a large and relatively recent impact crater. The trailing hemisphere is different. It shows a complex pattern of bright swaths on a background darker than the leading hemisphere. The swaths are thought to result from internal activity. Perhaps the bright material was extruded along lines of fracture at the surface. In any event the bright swaths fail to follow the kind of pattern that cratering would lay down on the surface. The zone containing the swaths is confined within a small circle at the center of the trailing hemisphere. The boundary be-



RHEA'S NORTH POLE was photographed by *Voyager 1* at a range of 80,000 kilometers. The pole itself is at the middle of the arc the terminator describes across this mosaic. The terrain to the west of the pole (toward the right in this image) is marked by large craters; in the terrain to the east such craters are missing. Presumably the large craters were made early in the history of the moon; the small craters both east and west were made later, after geological activity had given the terrain to the east of the pole a fresh, uncratered surface.

tween this zone and the bland leading hemisphere is diffuse.

The high-resolution views of Rhea made by *Voyager 1* show the equatorial region of the leading hemisphere somewhat to the east of the putative large, fresh impact crater. The best views show the north pole of the body, which *Voyager 1* flew over at a distance of only 59,000 kilometers. In each view Rhea is found to have a densely cratered surface much like the cratered highlands on the moon and Mercury. The principal difference is that the large, fresh craters on the moon and Mercury are surrounded by blankets of ejecta; the craters on Rhea are not. Presumably Rhea's weaker gravity is responsible. If Copernicus, a large crater on the earth's moon, had formed on Rhea, its ejecta would have been spread over most of the body's surface. On the earth's moon most of the ejecta lie no farther away than a few times the radius of the crater.

The nature and the origin of the bodies that cratered Rhea can be surmised from a mosaic of images showing the body's north polar region. At first the entire region appears to be uniformly pitted with craters. A closer examination shows that the western two-thirds of the polar mosaic is marked by a collection of craters with diameters ranging from 30 to 100 kilometers and in addition a dense population of smaller craters. The smallest ones visible are a few kilometers across. If other craters are smaller still, they are below the limit of resolution. The eastern third of the mosaic is also marked by small craters, but the larger craters are missing. A few subtle depressions in the surface are visible. They suggest that the larger craters in the east were filled or buried.

The difference between the two terrains implies a period of cratering in which projectiles with a wide range of energy formed craters with a wide range of sizes. At some point the remaining projectiles whose impacts could form large craters (craters greater than 50 kilometers in diameter) were swept up. The bombardment by the objects that formed the smaller craters continued. Meanwhile part of Rhea's surface was regenerated, perhaps by fluid extrusion from the interior or perhaps by the flow of a slurry of material driven to the surface by the pressure of gases accumulating within the moon. The resurfacing included the eastern third of the polar terrain. Estimates of the rate at which Rhea is being cratered by comets and asteroids today indicate that few of the visible craters (both large and small) in the images are recent. Hence most of the cratering must have come early in the history of the solar system, and it must have been intense. The projectiles could have been remnants of the accretion of gas and dust in orbit around the sun. They could have been remnants of the accretion of gas and dust in orbit around Saturn. They could also have come in pulses as the debris from bodies that collided in the early Saturnian system.

Dione

In sum, the appearance of Rhea suggests that at least two populations of projectiles marked the surface. The appearance of Dione, the next moon inward from Rhea, allows more detailed deductions. Dione travels in orbit around Saturn at a distance from the planet's center of 6.2 R_s. Its diameter is 1,100 kilometers. With a density of 1.5 grams per cubic centimeter it is the densest of Saturn's moons except Titan. The distant views of Dione made by *Voyager 1* showed a striking asymmetry between the leading and the trailing hemispheres. In the trailing hemisphere a network of intersecting bright streaks on a dark background was visible. It looked much like the trailing hemisphere of Rhea. The leading hemisphere was uniformly bright. Again the region of complex variations in albedo was confined within a small circle at the center of the trailing hemisphere, and again the boundary of this region with the bland leading hemisphere was diffuse.

Closer views of the trailing hemisphere made by *Voyager 1* showed that craters between 50 and 100 kilometers in diameter were crossed by the streaks. Therefore the streaks must have formed well after the torrential bombardment the craters imply. All things considered, the large craters on Dione and on parts of Rhea (including the western two-thirds of the polar mosaic) resemble the highland craters found on the earth's moon, Mars and Mercury. We shall refer to the projectiles that made such craters in the Saturnian system as Population I. The most likely hypothesis is that they resulted from the agglomeration of matter left in orbit around the sun after the solar system formed.

The closer views of Dione also showed plains where the density of cratering is far lower than it is on the "highlands." On the plains, however, the proportion of small craters to large ones is far higher. The proportion is that of the eastern third of the polar mosaic of Rhea. On both the plains of Dione and the terrain east of the north pole on Rhea the distribution of sizes among the craters resembles that of the craters surrounding the principal craters on the moon. It also resembles that of the craters surrounding the places on the earth where nuclear devices have been tested. In general the prevalence of small craters suggests the pocking of a landscape by the ejecta from the impacts of larger projectiles or by the fragments pro-

עזרא אוריון

בשליטה מרחוק

פסל על כוכב המאדים. דמיון פרוע? לא בדיוק. הפסל עזרא אוריון משדה־בוקר, כבר הגיש תוכניות מפורטות לביצוע ואפילו זכה לתמיכה: מנהלי מוזיאונים ומדעני חלל מעודדים אותו.

ובכל־זאת, איך יוצרים פסל על כוכב־לכת במרחק 300 מיליון ק"מ משדה־בוקר? פשוט מאוד: בשלט־רחוק. על המאדים ניצבת החללית האמריקנית „וייקינג". היא מסוגלת לחפור ולהזיז סלעים על־פי הנחיות הנשלחות אליה ממעבדות החלל של נאס"א. את הפסל שתיצור החללית נוכל לראות באמצעות שידורי תצלומים ממש כפי שצפינו בנחיתת האדם הראשון על הירח.

Aviation history and Lufthansa grew up together.

Lufthansa

ROGUES—SYGMA

Triumph at Kourou: toasts followed the departure of Flight 19 on Sept. 15 at the launch site in French Guiana

A Proud Ariane Again Takes Flight

Western Europe enjoys a success in the skies and makes plans for new programs

European space officials are jubilant and understandably relieved these days. On Sept. 15 Ariane Flight 19 had a successful lift-off from the European launch site at Kourou, French Guiana. That flight, crowned with champagne toasts and congratulatory cables, marked the end of a troubled 16-month period in which Ariane was grounded because of problems in its engine design. Furthermore, the success at Kourou gives Arianespace, the European-owned corporation that manufactures the launcher, a solid two-year lead over U.S. competitors. Ariane is now virtually the only contractor available outside the Communist bloc for launching commercial satellites, and that burgeoning market is estimated to be worth at least $1 billion a year.

The Ariane launch was a crucial step in re-establishing the self-confidence of the 13-member European Space Agency as it prepares to set its agenda for the next twelve years. An ESA ministerial meeting scheduled to be held in the Hague in early November will decide whether the agency should proceed with plans to build a European space shuttle, *Hermes*, which would be capable of carrying a three-man crew. *Hermes* will require the development of a giant Ariane-5 rocket, similar to the one used to lift the U.S. shuttles into orbit. Also to be debated at the Hague will be the question of European participation in the U.S. space station project in the 1990s.

A final matter on the agenda is whether to increase the agency's funding to around $2 billion annually for the next 15 years. This would be almost twice the amount currently provided by the 13 member countries.* France so far has paid 60% of the cost of developing Ariane, and West Germany 20%, but Britain has contributed only the minimum 3% required for membership and seems disinclined to increase its commitment. After learning this summer that the British government was not prepared to take a larger role in the space program, West Germany's Reimar Lüst, the director general of ESA, said bitterly, "Britain isn't needed anymore on its present terms of membership."

Besides setting the tone for the forthcoming meeting, the successful Ariane flight was a vindication of Europe's determination to stick to its space objectives despite competition from the American space shuttle. Ariane, which, unlike the American shuttle, is based on the concept of a use-it-once disposable launcher, had captured half the world satellite launch market before one of its rockets exploded shortly after lift-off in May 1986. But despite that accident, launch orders have continued to pour in. At present Arianespace is committed to launching at least 44 satellites by 1991. Next year ESA officials plan to order 50 Ariane-4 heavy launchers to replace the current Ariane-3 models. The even heavier Ariane-5 will not be ready until the mid-1990s. But by 1992, even though world demand for satellite launches is expected to begin dropping by that time, Arianespace hopes to be well enough established to be giving such U.S. firms as McDonnell Douglas, General Dynamics and Martin Marietta some uncomfortable competition.

Ironically, the Europeans might never have got into the satellite-launching business if NASA in the 1970s had not begun to resist the idea of launching non-American satellites that threatened to compete with what was essentially a U.S. monopoly. When France proposed developing the Ariane launcher in 1973, Britain, still irritated by the high costs of the Anglo-French Concorde supersonic aircraft, at first refused to help in the financing. West Germany also balked but finally agreed to cooperate. The need for such an enterprise is now so obvious that few would question it. Says ESA's Lüst:

*Austria, Belgium, Britain, Denmark, France, West Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden and Switzerland. Finland is an associate member, while Canada is a "cooperating member state."

"Without an independent access to space, Europe would not have been able to compete in the world satellite market."

The hottest space issue, from the European viewpoint, is the U.S. space station project, on which the Europeans are eager to collaborate. A space station will be the first step toward gaining entry to the rest of the solar system, as well as to potentially profitable new technologies that may become accessible in space. But the Europeans have not forgotten the slights they feel they suffered from the U.S. in the past. The U.S., for instance, originally offered to collaborate with ESA on building a motor for a space vehicle that would probe Halley's comet as it flew past earth last year. But when the U.S. planetary space program was gutted in the early 1980s in order to provide more funds for the shuttle, the Europeans were abruptly shunted aside. To the surprise of the U.S., ESA built its own vehicle, Giotto, and carried out the comet probe with great success.

On the space station program, the Europeans are therefore unsure about the reliability of their American partner. Some of the uncertainty comes from whether the U.S. will use the station for the Star Wars program or purely for scientific research. Europeans also complain that American officials are reluctant to share space technology with its Western allies. Says Lüst: "The basic point is that the U.S. has not yet realized that Europe has become a real space power."

Lüst believes good cooperation exists among U.S. and European space scientists, but others disagree. Geneviève Debouzy, head of the sciences division at the Centre National d'Etudes Spatiales (CNES), the French equivalent of NASA, feels that even the working relationship among scientists is breaking down. Says she: "I have the feeling that American scientists are turning in on themselves and becoming isolationist." As for cooperation between ESA and NASA, she adds, "we tell them what we do, and they tell us what they do, but there is no real cooperation. There is no access to American space vehicles."

Such doubts are likely to provide a powerful argument in favor of going ahead with construction of an independent European shuttle as a means of gaining access to the American space station, as well as perhaps Soviet stations. In addition, the Europeans are thinking of building several space structures that would be linked to the American station. The first would be an "attached pressurized module," a permanently manned laboratory for use in microgravity experiments that require continuous human monitoring. Another, an automated laboratory for six-month microgravity experiments, would be retrieved by the U.S. shuttle and serviced on earth. Still another, for long-term experiments in areas such as crystal growth, would be serviced in orbit by Europe's own shuttle, *Hermes*. At the Hague, members will discuss which, if any, of these projects will be pursued.

Hermes is clearly the key to Europe's future role in space. As presently envisaged, the shuttle would be 49.2 ft. long and have a wingspan of 32.8 ft. It would carry a payload of about three tons and have an ejection capsule that the three-person crew would use in case of emergency. On a mission to a man-tended space laboratory, the shuttle would stay in space for about a month and would be locked to the free-flying laboratory for perhaps three weeks. According to ESA estimates, the shuttle would remain operational for ten to 15 years.

Despite the recent surge in space activity, Europeans are well aware that in most respects they remain far behind the U.S. and the Soviet Union. On a per capita basis, Europe spends only one-sixteenth as much as the U.S. on space research. In 1985, before the *Challenger* accident, the U.S. launched 21 satellites, in contrast to Europe's five (including the spacecraft Giotto), Japan's two and China's one. The Soviets put up 116. Between 1957 and 1984, the U.S. launched 1,144 satellites, while the Soviets sent up 2,411. Says Lüst: "We should be under no illusions. The U.S. and the Soviet Union still have a significant lead, and it seems unlikely that European governments will be persuaded to make good the gap in resources."

Even so, the Europeans are trying to move ahead by using their money effectively and avoiding some of the pitfalls that have plagued the U.S. program. Says CNES's Daniel Sacotte: "Man in space is an imperative. The question is, what role will he play in space? We don't yet have a fixed concept or objective. But we have chosen the direction in which we want to develop." —*By William E. Smith. Reported by William Dowell/Paris, with other bureaus*

NOGUES—SIPA

A two-year lead over U.S. competitors: engineers in control room at Kourou monitor lift-off two weeks ago

RALPH MORSE

Scene of desolation: Pad 39B at Kennedy Space Center, where mighty rockets once blasted off for the moon, stands empty

Crippled Birds in Search of Wings

Earthbound and demoralized, the U.S. looks uneasily to the future

Not since the orbiting satellite Sputnik 1 first beep-beep-beeped its way across the night sky 30 years ago have the Soviets mounted a more palpable challenge to U.S. technological prowess. President John F. Kennedy responded to the original challenge in 1961 by proclaiming that Americans would land on the moon within the decade, and so they did. Today there are no such stirring commitments. The only manned spacecraft orbiting the earth is the Soviet space station Mir.

"The United States," says ex-Astronaut Joe Allen, who flew on shuttle missions in 1982 and 1984, "is flirting with becoming to the space age what the Portuguese were to the sea age." Says another space insider: "You know, 30 years ago everybody's worst fears were that the Soviets would win the space race, and now the space capital of the world really is Moscow. This mess isn't something that just came up after *Challenger*. For years there has been no [expletive deleted] program." Rick Hauck, who will command the first post-*Challenger* shuttle flight, is worried by signs of political paralysis in Washington. "We must decide what we really want to do," he says. "We need to be clear about our goals."

While the U.S. space program is grounded, these questions are under study by a high-powered klatch called the Senior Interagency Group for Space. Its members, convened by the White House to reassess U.S. space policy, include representatives from the Pentagon, State Department, CIA and other agencies. Although the unit is scheduled to report to President Reagan next month, senior members began meeting only last week. Concludes Florida Congressman Bill Nelson, chairman of the House Space Science and Applications Subcommittee: "Reagan has shown no leadership in space."

Basic questions about the direction of the U.S. space program therefore remain unresolved. Among the most pressing:

- Should the U.S. concentrate on the Strategic Defense Initiative, as President Reagan and the Pentagon urge, or should it preserve its traditional commitment to the peaceful exploration of space, perhaps in cooperation with other countries, including the Soviet Union?
- Should the U.S. remain committed to the shuttle program, as NASA wants, or should it invest heavily in expendable rockets, as the Air Force prefers?
- Should NASA organize commercial uses of space, as the governments of foreign nations are doing, or should that be left to private business, as the White House insists?
- Should U.S. space probes concentrate on colonizing the moon? Or Mars? Or both? Or other planets? Are such probes to be manned or unmanned?
- Should the purposes of NASA, which one expert calls an "agency without direction . . . demoralized," be redefined?
- In an era of multibillion-dollar deficits, what price is the U.S. prepared to pay to regain its pre-eminence in space? NASA Chief James Fletcher has trimmed his budget request to $9.5 billion in the coming fiscal year.

Some answers have been offered. Former NASA Administrator Thomas O. Paine, for example, was assigned by the White House to make a major study of the space

RALPH MORSE

Technician works on heat tiles of *Discovery*, the space shuttle that is scheduled to fly sometime next summer—maybe

OCTOBER 5, 1987 No. 40

TIME

Caught in The Act

Moscow Takes the Lead

An Inside Look at the Soviet Space Program

Energia Rocket Blasts Off from Baikonur Cosmodrome

AUSTRIA	S 36	GERMANY	DM 4.50	ISRAEL (incl. tax)	NS 3.50	NORWAY	Kr 16.00	SWITZERLAND	F 4.00
BELGIUM	F 100	GIBRALTAR	£1.20	ITALY	Lit 3200	PORTUGAL	Esc 270	UNITED KINGDOM	£1.20
DENMARK	Kr 17.00	GREECE	Dr 280	LUXEMBOURG	F 100	SPAIN	Pta 300	U.S. ARMED FORCES	$2.00
FINLAND	Mk 12.00	ICELAND (incl. tax)	Kr 75.00	NETHERLANDS	Fl 5.00	SWEDEN	Kr 16.00	YUGOSLAVIA	ND 950
FRANCE	F 16.00	IRELAND (incl. tax)	IR£1.30						WEEKLY

military reasons. Besides, the national prestige resulting from a visit to Mars would be immense.

The greatest problem: the physiological stress of a mission that could take up to three years. The Soviets learned early that humans are not built for a low-gravity environment. On an early long-duration flight in 1970, which lasted 18 days, the cosmonauts did no physical conditioning. After they landed, it was almost three weeks before they could walk. Now it is well established that space travelers begin to lose muscle tone almost immediately and that calcium starts leaching from bones in low-gravity environments. Today, thanks to intensive Soviet research, their space explorers returning to earth from 200-day-plus missions can walk unaided in three days and recover completely within three weeks.

In earth orbit aboard Mir, Mission Commander Leonid Kizim goes about his everyday routine in near-zero gravity

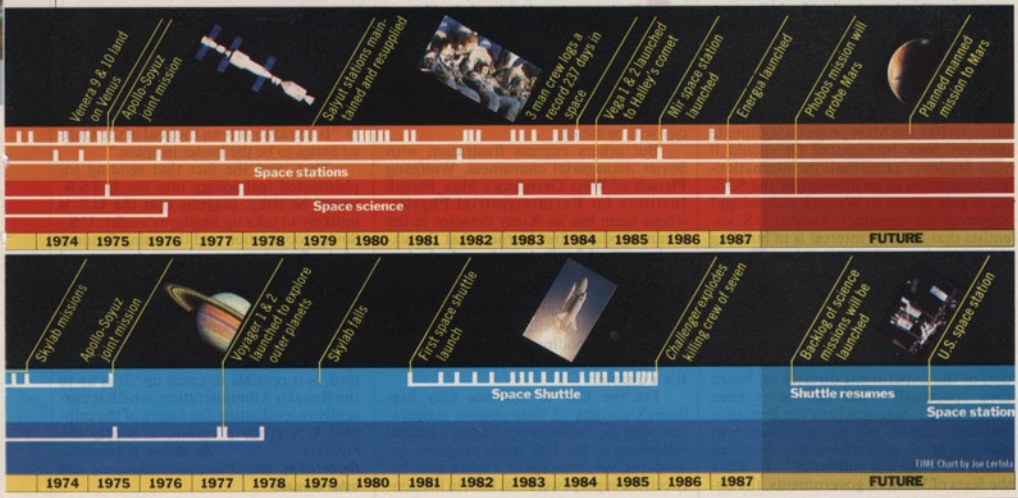
The prescription: constant physical therapy. Each day, Mir cosmonauts put in an hour on an exercise bicycle and another on a treadmill. For 16 hours a day, they are required to wear a suit criss-crossed with a web of elastic cords so that any movement in any direction forces the cosmonauts to strain against the counterpressure. It is no pleasure. "They do it because their health depends on it," says Deputy Flight Director Blagov. "They cannot miss a single day. Without the work load, there may be calcium loss and decrease in leg muscles. The body takes away what it doesn't use." Sagdeyev is convinced that the health dangers of a Mars mission would be manageable. "The first year is O.K.," he says, "so two or three years are probably also O.K."

Psychological problems too are likely on a long flight. To keep motivation sharp and productivity high, the Soviets pay plenty of attention to the space station's livability. The interior of Mir, for example, has been painted in two colors to provide the crew with a sense of floor and ceiling. On Mir, cosmonauts get two days off each week and have special radio hookups so they can talk with their families and with virtually any sports figure, scientist, or celebrity they choose.

The Soviets have shared their knowledge about long-term spaceflight, mostly through informal contacts rather than formal publication. Says one NASA specialist: "We have a book summarizing these lessons. We've got their diets. We try to make our people very aware of what the Soviets have done, because our own experience is all short duration and our data base is very old." Nonetheless, says Nicholas Johnson, author of the book *Soviet Year in Space*, "the Soviets still have much to learn before they can reasonably responsibly put together a Mars mission." They need, for example, a reliable propulsion system for their interplanetary space capsule; at least two of the later Salyut systems had propulsion failures. The Soviets are also weak, Johnson says, in communications technology. "They know they do not have the best technology," he observes. But they are working on it.

Similar shortcomings plague the *glasnost*-proof, supersecret Soviet military space program. At any one time, say U.S. intelligence analysts, the U.S.S.R. is operating some 150 satellites, and perhaps as many as 120 are believed to be performing military missions. For hours each day, these experts say, Soviet Cosmos military satellites drift over the U.S., photographing missile silos and naval deployments. Other Soviet spacecraft lurk with sensitive electronic ears that can pick up telephone conversations in Washington, while Meteor weather satellites monitor conditions over key U.S. targets. Soviet infrared satellites watch for the telltale heat signaling a launch of U.S. ICBMs. At the military launch site in Plesetsk, 500 miles northeast of Moscow, crews stand ready to launch additional intelligence satellites at a moment's notice.

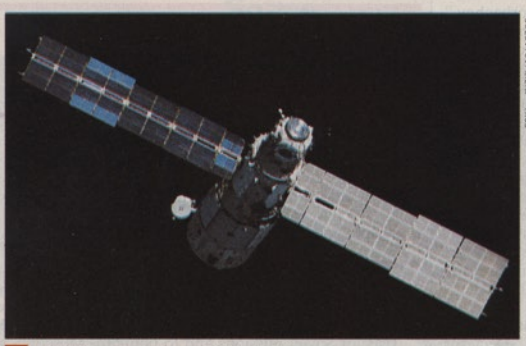
"They have a very active military space program in numerical terms," says Paul Stares of the Brookings Institution,



ing minilander to record data on the moon's soil. One experiment involves a laser that will emit short bursts of energy, each vaporizing a square millimeter of surface into a cloud that can be analyzed by the probe's spectrometer. "You can pick up such exploded material from many different places," says Sagdeyev. "In the end you have a chemical map of the surface of Phobos—if you are lucky."

But there is more than luck involved, as Western experts make clear. "The Phobos mission," says Cornell Planetary Scientist Carl Sagan, "is not just world class. It is novel, diverse and appropriate. The whole idea is very clever." Notes Gerhard Neukum, of the German Aerospace Research Establishment: "The Mars mission is fantastic. It carries a huge set of instruments. They did it with Venus. Now they have focused on Mars, and it is to be expected that they will be equally successful." In fact, each of the probes will carry 25 instruments—an enormous number, considering that the U.S.'s complex, much delayed Galileo probe to Jupiter has only 16.

Sagdeyev has even higher expectations for the Mars Sample Return mission, now being planned for the late 1990s. The idea is for the spacecraft to make a soft landing on the planet and send a rover to gather soil samples on a yearlong trek over the surface. Then about 2 lbs. of material would be returned to earth for detailed analysis. In Sagdeyev's plan, the U.S. would supply the rover, plus advanced electronics to guide it from an orbiting mother ship.



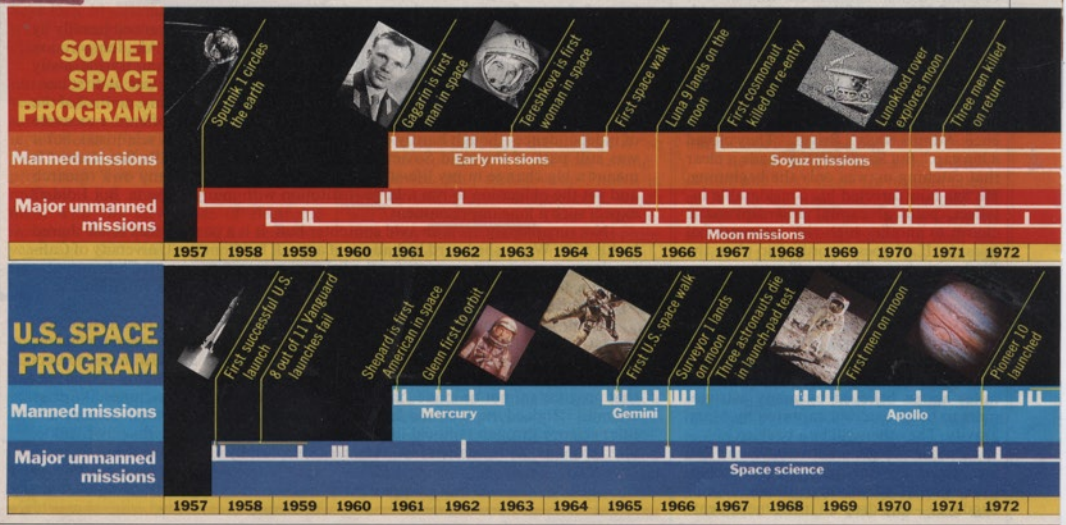
The Mir space station, with its winglike solar-energy panels extended, has been designed for permanent occupation

Sagdeyev's enthusiasm for robot probes, however, brings with it an inevitable tension: in the U.S.S.R., just as in the U.S., the unmanned and manned programs compete for budget dollars, and so far the manned missions have been the big winners. But, says Sagdeyev, "99% of what man can do in space can be done by robots." Predictably, the statement irritates his comrades at Soviet mission control. "This crew has done 100 repair jobs," scoffs Victor Blagov, the deputy flight director, arguing that humans are needed to deal with unanticipated situations. Snaps Stepan Bogodyazh of Glavkosmos, the Soviet equivalent of NASA: "You need people there to test the instruments. The cosmonaut is a researcher and this is a laboratory."

As with their unmanned missions, the Soviets have made a virtue of slow, steady progress in the manned program. While the U.S. jumped quickly from orbital flights to moon missions to the now defunct Skylab to the shuttle, cosmonauts have steadily plied earth orbits for nearly three decades. The Soviets perfected their launch techniques by using substantially the same rocket that sent Gagarin into orbit in 1961. And while they lost the race to the moon for want of a large booster, they remedied the situation last May when the 170 million-hp Energia rocket blasted off its pad at the Baikonur Cosmodrome, near Tyuratam in Soviet Central Asia.

The new rocket will make possible the deployment of larger, more sophisticated Soviet space stations. Says Bogodyazh: "There will be a Mir 2." Explains Alexander Dunayev, head of Glavkosmos: "Space stations weigh up to several dozen tons. What's needed are stations that weigh several hundred tons. We should soon learn to build big structures out there, not tens of meters but kilometers across, multifunctional platforms. Cosmonauts may well live there permanently. And from these structures, there may be flights to other planets." If so, then first on the agenda, undoubtedly, would be Mars.

The lure is strong. Mars is the only other known planet that may be habitable—and thus the only realistic location for a space colony. That makes it a logical target for the the Soviets, who are committed to establishing a permanent presence in space for both scientific and



ence program years before Gorbachev."

Sagdeyev's era might have been short-lived except for one thing: it produced results. Among the first breakthroughs were Venera 9 and 10, projects started by Sagdeyev's predecessor, Georgi Petrov. In 1975 the two probes transmitted the first photographs of Venus' hellish surface. Imagers on the next two probes failed, but Nos. 13 and 14 sent back color photos plus a wealth of information on atmospheric, surface and subsurface chemistry. Then in 1983 came a pair of missions that stunned Western space scientists. Venera 15 and 16, in Venus orbit, transmitted high-resolution radar maps of the planet's surface. The maps, says Beggs, "indicated a level of radar technology that we had not given the Soviets credit for." Declares Masursky: "They did first-class work."

Sagdeyev was already embarked on another project, one that could have ended his career. Called Vega, the mission was designed to approach and study Halley's comet. Sagdeyev chose to build Vega around the proven, off-the-shelf technology of the Venera probes. But he wanted the scientific instruments to be custom designed, even though the expertise was not available within the U.S.S.R. So he recruited scientists from nine countries, including the U.S., to join the project. That was unheard of in security-conscious Soviet space circles. Recalls Sagdeyev: "Sometimes my opponents, in order to take over, were almost ready to say that I was too much for foreign cooperation. But if you have a belief that what you are doing is right, you can survive difficult times."

The gamble paid off spectacularly. On March 4, 1986, having swung by Venus to drop off scientific probes, Vega 1 trained its camera on the comet, then less than 9 million miles away, and relayed high-quality pictures to earth. Two days later, it came within 5,500 miles of the comet's heart. Although pelted by dust, Vega 1 revealed for the first time the dimensions and dynamics of the ten-mile-long nucleus.

The Vega mission put the world on notice that the Soviet Union would not take a back seat to anyone in space science. Admits NASA's Briggs: "They closed a big gap." But Sagdeyev has made it clear that catching up was only the beginning. He has now directed his considerable intellect, political capital and diplomatic charm to another high-risk international mission. If all goes according to plan, the Phobos probes will take off next summer for Mars. When they reach the Red Planet some 200 days and 118 million miles later, they will orbit for a time, taking data on solar physics. The first Phobos will match orbits with the moon for which it is named, a chunk of rock about 14 miles across believed by many astronomers to be an asteroid captured by Mars' gravity. The other will be a backup.

Phobos will glide between 98 and 260 feet above the moon's surface—"something similar to a cruise missile," quips Sagdeyev—and drop an instrument-bear-

The Wizard of IKI

Wearing a stylish pinstripe, double-breasted suit, Roald Sagdeyev, the director of the Soviet Space Research Institute, began by disarming the group of Cornell astronomers during a recent U.S. tour with a folksy story about a Russian woodsman. Then, in a voice strained from singing *When the Saints Go Marching In* to Soviets and Americans gathered at the Chautauqua Institution, he discussed the dangers of nuclear weapons and the U.S. Strategic Defense Initiative (SDI), or Star Wars. Finally, the trim, 5-ft. 8-in. physicist, who rarely drinks and never smokes, concluded with his vision for a joint U.S.-U.S.S.R. mission to Mars. The performance was vintage Sagdeyev: a mixture of wit, charm and trenchant observation.

Besides being an accomplished scientist and administrator, Sagdeyev is the Soviet Union's chief space diplomat. He spent more than two weeks in August flying from the U.S.S.R. to Hawaii, New York and Washington to recruit scientists for Soviet missions and to publicize Moscow's space program. His dizzying schedule of speeches, meetings and interviews has forced him to all but abandon his dacha outside Moscow and even his burning passion, chess. In recognition of his achievements at the Soviet Space Institute (IKI), he was chosen to head the Soviets' new Supercomputing Institute and was appointed as Soviet Leader Mikhail Gorbachev's special adviser on the U.S. Star Wars program.

Born in Moscow, Sagdeyev, 54, once planned to become a mathematician, like both of his parents. But as a student at Moscow University in the mid-1950s, he switched majors to study physics. "A physicist can still enjoy the beauty of mathematics and have a more intimate interaction with nature," he says. Sagdeyev also took up English, which he calls the "first necessity for a scientist." He passed along his appreciation of the language to his son and daughter, both computer scientists, and to his two small grandchildren.

Sagdeyev: wit, charm and trenchant observation

While working on nuclear-fission control at the Soviet Institute of Atomic Energy in 1958, the young scientist was stunned by his first meeting, in Geneva, with scientists from outside the Soviet Union. He still relates the experience with wonder: "For the first time I met foreign scientists, Americans, doing the same job and reporting their results. It was like meeting extraterrestrials—extraterrestrials working with the same laws of physics. It was exemplary proof that science has no borders."

Sagdeyev increasingly found traditional Soviet science, influenced heavily by Communist Party politics, stifling. In 1961 he helped found Akademgorodok (Science City), an informal think tank located in the Siberian countryside, away from the intensely political atmosphere of Moscow. Sagdeyev was at first concerned about neglecting his research when he was asked to assume control of the struggling space-science program at IKI in 1973. The position offered a measure of independence (though hardly on a level enjoyed by top NASA scientists), but it was still part of the rigid Soviet scientific bureaucracy. Recalls Sagdeyev: "It meant a big change in my life-style. There was a desire to do my own research and yet the obligation to run a large institution with many projects. But I didn't expect such a long imprisonment."

Not surprisingly, he is an avid computer buff. It is a passion that is not shared by his wife. When she heard he had spent a small fee from the University of California on computer equipment for the Soviets' Young Cosmonaut Club, an organization for youngsters interested in space, she sighed with a smile and said, "There goes my fur coat."

Sagdeyev continues to speak out against Soviet practices that restrict research. Besides publicly criticizing the dismal state of Soviet astrophysics, he has overridden official Soviet reluctance to provide computers and electronic copiers to scientists. Sagdeyev recently told members of the Soviet Academy of Sciences that progress cannot be made "until we stop treating copying machines like class enemies." Indeed, he is all too familiar with the damage done when researchers filter science through political ideals. The principle, he notes with a sly twinkle, also extends to scientists in the U.S.—especially to those who support "your SDI."

—*By Dick Thompson/Moscow*

PUSHAROVA—TASS

Flight controllers in Kaliningrad monitor linkup of Kvant module with Mir; Energia poised for lift-off last May

ed their reputation for gathering impressive scientific data from space.

The Soviets' launch capability took a quantum leap earlier this year when they successfully fired off Energia, a booster as powerful as the mighty Saturn V, which the U.S. developed for the Apollo program and then scrapped in favor of the shuttle. With Energia, the Soviets can loft 100-ton payloads, vs. a maximum for the U.S. shuttle of 30 tons. That is enough to carry their shuttle, which is under development, or to orbit parts for a space station far larger than Mir, which could be a platform for a manned mission to Mars. Says Dale Myers, deputy administrator at NASA: "Energia is a pretty impressive machine. I would sure like to have it."

For all these accomplishments, Soviet microelectronics and computers are ten years behind those of the U.S. Military satellites sometimes break down in a matter of weeks. Photoreconnaissance satellites literally drop their film to earth for processing. The ultraconservative Soviet military is just now beginning to experiment with the techniques of electronic imaging developed by U.S. scientists years ago. Still, admits Geoffrey Briggs, NASA's director of solar system exploration: "It's not clear that you need state of the art to be effective."

The Soviet drive into space is taking place while American space efforts are all but moribund. The U.S. space program has been virtually closed down since the space shuttle *Challenger* exploded in midair 73 seconds after lift-off in January 1986, killing all seven astronauts aboard, including Teacher Christa McAuliffe. The tragedy was more than a setback for NASA. It exposed the agency as an unwieldy, indecisive bureaucracy unsure of its direction and increasingly beset by the demands of the military and the Reagan White House *(see following story)*.

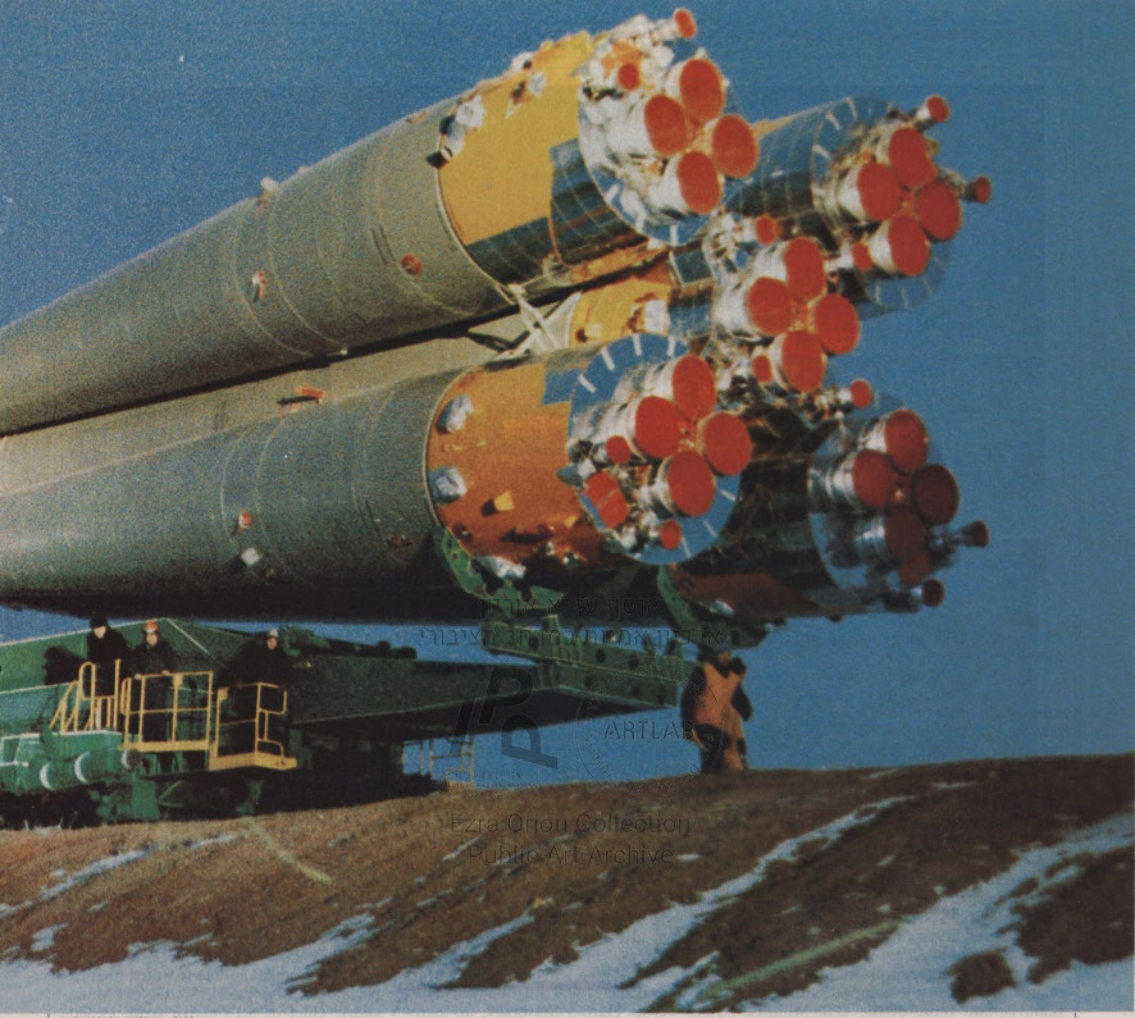
NASA could handle awesomely complex missions like the Apollo landing on the moon in 1969 as long as it had plenty of money and control. But it has never established a long-range vision of the U.S. role in space. After its budget was cut in the early 1970s, the agency promised far more than it could finally deliver with the shuttle program. Even if launches resume on schedule, the orbiter *Discovery* will not fly until June 1988.

Meanwhile the Soviets are moving ahead. Next July, the ambitious twin Phobos probes should be on their way to explore Mars and its moons. It is a mission worthy of Jules Verne. Harold Masursky, an astrogeologist who worked on the U.S. Viking missions to Mars, says the concept is "so damn complicated, it's just hair-raising." The Soviets plan to follow up Phobos in 1992 by lofting another spacecraft, which will analyze Martian soil. Later in the decade, they want to use an unmanned probe to bring pieces of the planet back to earth, and have boldly suggested that the mission be jointly undertaken with the U.S.

But complex scientific missions are only part of the Soviet push to dominate space. They are aggressively marketing their workhorse Proton boosters as a low-cost alternative to the European Space Agency's Ariane, China's Long March and, eventually, private U.S. rockets for launching commercial satellites. The Soviets are offering to sell high-resolution satellite photos of earth that could be used for mapping and assessment of agricultural and mineral resources. And they plan to continue occupying Mir, which has been in orbit since February 1986. The space station has already been outfitted with an astronomical observatory module named Kvant. Additional modules are planned for materials processing, earth observation and biomedical research.

The Soviet space program had several notable early successes, including Sputnik 1, the first pictures from the dark side of the moon in 1959 and the first man in space, Yuri Gagarin in 1961. But its planetary-science program did not really take off until shortly after the appointment in 1973 of a 40-year-old scientist named Roald Z. Sagdeyev as head of IKI. From the outset, Sagdeyev started to shake things up. He took physicists out of their labs and put them on production lines to watch their experiments being built. Says Georgi Managadze, chief of IKI's active space experiments lab: "Sagdeyev follows every stage of manufacturing and testing."

The new director took some unprecedented and risky steps. He brought talented Jewish scientists into the institute. He began building a corps of young scientists and selecting projects based on their scientific value rather than the political standing of scientists. He fought for access to computers. Most important, and politically riskiest, he introduced a potent measure of democracy into the Soviet program. "Before Sagdeyev," says Louis Friedman, executive director of the U.S. Planetary Society, "the Soviet space program was closed. Now they talk about their plans. They even argue in public. He has materially changed the way they do major projects." Declares Thomas Donahue, chairman of the National Academy of Sciences' space science board: "He introduced *glasnost* into the space sci-



PUSHKARYOV/KUZMIN—TASS

An SL-4 booster rocket, the workhorse for Soyuz manned missions, on railway to the launch pad at Baikonur Cosmodrome

Such self-assurance on the part of the Soviet space establishment will be in ample evidence this week as IKI and its charismatic director, Roald Sagdeyev, sponsor a three-day extravaganza of seminars and speeches celebrating the 30th anniversary of the launch of Sputnik 1 in 1957. Called Space Future Forum, it will focus on the topic of international cooperation in space. Some 500 scientific luminaries from around the world plan to attend.

The Soviet conference is evidence that in their space program openness is not just political fashion. Says Geneviève Debouzy, of the French space agency: "The seminars that ten years ago would have been given at the Goddard Space Flight Center are now given in Moscow." To the surprise of Americans, the Soviets' well-deserved reputation for a plodding, low-tech, assembly-line approach to space exploration has paid off. Says James Beggs, former NASA administrator: "There's been a habit in this country of thinking of the Soviets as stupid and that they steal all their technology. That's just not so."

Indeed, space experts in the U.S. and Europe are now conceding publicly what they would have found laughable a decade ago: although the Soviets lag far behind in electronic gadgetry, they have surged past the U.S. in almost all areas of space exploration. If unchallenged, Moscow is likely to become the world's dominant power in space by the 21st century. Says Heinz Hermann Koelle, a West German space-technology professor and former director of future projects at NASA's Marshall Space Flight Center: "American pre-eminence in space simply no longer exists." Warns James Oberg, an expert on the Soviet space program: "If the Soviets can aggressively exploit this operational advantage, they can make us eat space dust for a long time to come."

In sheer numbers of launches per year, the Soviets inched past the U.S. in 1967, 66 to 58, and have stayed in front since. In 1982 they sent up 101 space shots, in contrast to 18 by the U.S. More impressive, Soviet cosmonauts have logged some 14 man-years in space, against less than five for U.S. astronauts. The knowledge of Soviet doctors and researchers about the medical and psychological consequences of long-term space habitation far outstrips that of their American counterparts. And with the twin Vega space probes, which photographed Halley's comet in 1986, Soviet scientists consolidat-

COVER STORIES

Surging Ahead

The Soviets overtake the U.S. as the No. 1 spacefaring nation

Dominating one wall of the control room was an enormous display screen showing a map of the world. Superimposed on the map, a line traced the orbit of the Mir space station, with rings along it representing ground stations. Mir's position was marked by a blue-green light, which was moving slowly across the circle centered on Moscow. The flyby would take only eight minutes, after which the window of communication would close. The audio feed came through with startling clarity, as if Cosmonaut Yuri Romanenko were standing in the next room. "The work here is very interesting," he said in response to a question that had been posed in writing by TIME *Correspondent Dick Thompson. "It brings us a lot of satisfaction."*

How does Mir compare with earlier Soviet space stations? "There is much more space," said Romanenko. "There is even room that can be used for living room. Atmospheric conditions are better, and all the instruments provide for good fresh air. It's much better than Salyut." Before another question could be asked, the light left the Moscow circle; the window had closed. Though all too brief, it was an extraordinary, exclusive exchange between a U.S. journalist and an orbiting Soviet cosmonaut.

Just a few years ago that encounter in the Soviet Flight Control Center at Kaliningrad, a suburb 15 miles northeast of Moscow, would have been unthinkable. In the closed world of the Soviet space program, the most impressive launches were rarely announced in advance for fear of failure. Even then, the barest details were released afterward—and only if the mission went just as planned. These days that characteristic secrecy seems to have evaporated, been replaced with a confidence bolstered by the dawning international recognition that Soviet achievements in space are fast outstripping those of the U.S.

The new dynamism is drawn from a spirit of *glasnost*, or openness, that preceded the revolution Soviet Leader Mikhail Gorbachev is striving to bring to Soviet society. Moscow's venerable Institute of Space Research (known as IKI, its Russian acronym) now bustles with the comings and goings of an increasingly youthful, independent-minded cadre of Soviet space specialists. And along with them are growing numbers of foreign colleagues, many of whom have been invited to add their experiments to Soviet space missions. Visiting scientists need only a pass to wander the halls freely.

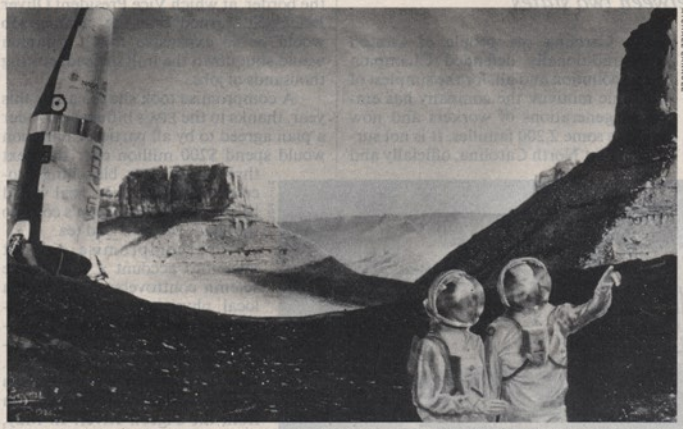
אפר'ל
-98

מדרשתון

פיסול במערכת השמש

עזרא אוריון שלנו, מגיע עד למאדים...
ב- 8 למרץ פורסמה כתבה ב"מעריב" בנושא "אמנות עתידית בחלל". בכתבה הוזכרו נסיונות הפיסול של עזרא אוריון במערכת השמש.
עזרא נמצא בקשר עם סוכנות החלל האמריקאית כבר משנת 1982. כבר אז נפגש עם מדען בכיר מהמעבדות להנעה סילונית ושוחח איתו על היתכנות של שילוב פיסול מדברי בפעילות על המאדים.
ב- 1985 פרסם כתב העת היוצא לאור בקליפורניה- LEONARDO מאמר על הפיסול שלו "פיסול במערכת השמש".
ב- 1988, כבר עלתה בו המחשבה לבצע קו אבנים על שפת מצוק VALLES MARINERIS שעל המאדים.
באפריל 1992, שוגרה **סופר-קתדרלה I** - (אלומת קרני לייזר) מחצי הכדור הצפוני, מ- 7 תחנות לייזר, מיליארד ק"מ גובהה, במהירות האור, בניצב למישור שביל החלב. עכשיו בודק עזרא את האפשרות לנצל את נחיתתו של ה- PATH FINDER לפיסול נוסף ברחבי המאדים.

תל'



MICHAEL CARROLL

Cooperative exploration: beyond the allure, the dream faces formidable barriers

Pros and Cons of a Flight to Mars

A modest Gorbachev proposal gets an ambivalent U.S. reception

For years, U.S. and Soviet space scientists have agreed that Mars is a tantalizing target for exploration. Fragmentary data suggest that the planet may once have possessed a denser atmosphere, a warmer climate and even bodies of water. Many questions about life on Mars remain unanswered. So when Mikhail Gorbachev again declared only days before the Moscow summit that the U.S. and Soviet Union should "cooperate on a flight to Mars," ears perked up in labs and offices from Los Angeles to Moscow. Even the Reagan Administration, which has balked at similar Soviet overtures, was at pains not to dismiss out of hand Gorbachev's conciliatory-sounding proposal.

Despite the obvious allure of Gorbachev's space suggestion, which will be formally presented to President Reagan this week in Moscow, U.S. experts in and out of Government are ambivalent about the feasibility of an actual joint expedition to Mars. At best, they point out, the success of any joint mission would rest on the fragile foundation of the Soviet leader's revival of détente with the West. Could good relations between the superpowers, they ask, last long enough to complete, say, a ten-year project? "There are potential benefits to us from such a mission," says U.S. Space Watcher Nicholas Johnson. "But there is great uncertainty about the political environment."

While the General Secretary left the details vague, Soviet and American space scientists have long discussed the broad outlines of a joint mission. The most probable venture, an unmanned mission in 1998 to bring Martian soil back to earth, would blend the strengths of the two nations' space programs. "The Soviets have the ability to put massive amounts of material into space," says John McLucas, a NASA adviser and a former Secretary of the Air Force. "But they rely on other countries to supply a good fraction of their instrumentation. We do things in a more refined way and get better data."

As now envisioned, the mission to collect samples would require separate U.S. and Soviet launches. With their heavy-lift launcher Energia, which can boost payloads at least three times as great as those on the U.S. shuttle, the Soviets would provide an extra capability to ensure sufficient backup fuel supplies. They believe they can deploy a space shield or parachute to slow their spacecraft enough to enable it to enter orbit around Mars without the use of retrorockets that draw on precious fuel supplies. Soviet scientists concede that this "aerobreaking" technique is still experimental.

The major U.S. contribution would be an "intelligent" ground vehicle. The robot rambler, which resembles the "moon buggy" used in the Apollo moon landings, would be used to gather and analyze soil samples. It must be able to find its way around the Martian surface, guided by an advanced artificial-intelligence "brain." It would then deposit the soil samples in a special canister that would be blasted aloft to the Soviet orbiter for the trip home. The 1976 U.S. Viking Lander probes, by contrast, could only radio data from soil samples back from Mars. This time, the samples would be returned to earth aboard the Soviet craft after a period of quarantine, possibly aboard an earth-orbiting space station. Says a NASA official: "It's a scheme that has a lot of attractive aspects." Estimated cost to the U.S.: a cool $2.5 billion and six years of prelaunch labor. The round-trip mission itself would take two years.

NASA

Happier days: the Apollo-Soyuz linkup

Missions vulnerable to shifting politics.

The scenario, however, has its detractors. For starters, Reagan Administration officials are concerned about giving away valuable high-tech secrets. And though work on the robot rover is under way at the Jet Propulsion Laboratory in Pasadena, Calif., the machine is several years away from being ready for such a mission. Besides, notes McLucas, "there are language problems, cultural problems. Management is much more difficult with more parties getting into the act." Nonetheless, M.I.T. Planetary Physicist Gordon Pettengill believes such a mission should be technically feasible "before 1998."

Even so, there are other, more formidable barriers. Past cooperative space ventures have been closely tied to politics. The 1975 Apollo-Soyuz mission, for example, sprang from an earlier era of détente. The costly linkup between the orbiting U.S. and Soviet capsules (price tag: $300 million) was promoted to test compatible docking systems but had little scientific value: the flight was the last for the Apollo program. Prospects for more joint missions disappeared in December 1979, when the Soviets invaded Afghanistan. "These missions start for policy reasons and stop for political reasons," says Nancy Lubin, a Government expert in U.S.-Soviet space cooperation. States NASA Administrator James Fletcher flatly: "Any major expenditure of money is not likely. We couldn't do much more than study the thing."

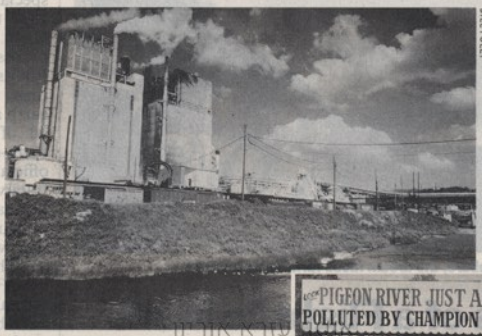
Although the case for a joint mission may be compelling to some, both scientists and Government officials are keenly aware that any cooperative exploration of Mars—and the advances in space science it would make possible—would be vulnerable to the shifting political winds in Washington and Moscow. As the summiteers convened in the Soviet capital, U.S. scientists hoped that the President and the General Secretary would do more than give the idea diplomatic lip service. —*By Dick Thompson/Washington*

A Big Stink on the Pigeon

Industrial wastes spark a war between two states

From its source on North Carolina's Black Mountain to the town of Canton, 22 miles away, the Pigeon River is a clean and lovely stream, lively with trout and tourists. By the time it leaves Canton (pop. 5,000), flowing toward and finally into Cocke County, Tenn., 50 miles away, the Pigeon has been transmogrified into a sludgy mess that looks like oily coffee and smells as bad as rotten eggs. The cause of this revolting change: industrial wastes that Champion International Corp. has been dumping into the Pigeon since the company opened a paper mill in Canton 80 years ago.

Since then, across the state line, the pollution has provoked indignation that sometimes seems as rank as the river itself. On the Tennessee side, people complain that the river's repugnant color and stench contribute to Cocke County's prolonged economic doldrums by discouraging tourists and development. With an unemployment rate currently averaging 15%, Cocke Countians openly envy the relative prosperity in Haywood County, home of the paper mill (present unemployment average: 6%). Says Cocke County Chamber of Commerce Executive Director Robert Seay, co-founder of the Dead Pigeon River Council, which wants to clean up the stink: "It's completely unfair for one county to use the river and have a [low] unemployment rate, and 50 miles downstream here we are with one of the highest unemployment rates in the state." In North Carolina the people of Canton have traditionally defended Champion Corp., pollution and all, for the simplest of economic motives: the company has employed generations of workers and now supports some 2,200 families. It is not surprising that North Carolina, officially and otherwise, has long ignored protests from Tennessee, choosing in 1985 to approve a five-year extension of Champion's wastewater discharge permit, even though residents of Cocke County communities begged to have a say in the matter.



BILL FOLEY

FOLEY

Champion's offending paper mill
A source of jobs and sludge.

Nor is it surprising that at last the Tennesseans went to court. Their aim was to force the federal Environmental Protection Agency to set standards requiring Champion to lighten the color of the mill's effluents. But North Carolina and Champion continued to resist in court and out. The company bused thousands of employees to public hearings on both sides of the border, at which Vice President Oliver Blackwell warned that the cleanup job would be so expensive that Champion would shut down the mill instead, costing thousands of jobs.

A compromise took shape earlier this year, thanks to the EPA's influence. Under a plan agreed to by all parties, Champion would spend $200 million over the next three years on a bleaching process for its wastes. Its goal would be to change the Pigeon's color to the shade of weak iced tea.

The compromise did not take into account a new, more solemn controversy. Last year a local physician noticed an unusually high number of cancer-related deaths in the tiny riverside hamlet of Hartford (pop. 300), whose people have always been accustomed to eating fish from the Pigeon River. In May, after EPA tests detected tiny traces of cancer-causing dioxin in fish from the Pigeon, the survivors of one husband and wife, who died of cancer within a month of each other, filed a $6 million wrongful-death suit against Champion. The dioxin controversy may tempt Cocke County to take a second look at the compromise plan to improve the Pigeon's color. For the moment the Tennesseans are awaiting further EPA tests, due this summer, that might provide some answer to an urgent question: Does the Pigeon not only stink but actually kill?

—By Frank Trippett.
Reported by Joseph J. Kane/Hartford

Grapevine

Clubbing an issue to death. Democratic Chairman Paul Kirk got it wrong when he called George Bush an "élitist Republican country clubber." The Vice President no longer belongs to any country clubs, though during his days in Texas he was a member of three exclusive Houston clubs that reportedly did not admit blacks. Bush is, however, on the rolls of one of the most selective clubs of all: the all-male Bohemian Club, a secretive California fraternity known for its odd rites, including skinny-dipping and bawdy skits. Among his fellow Bohemians: Ronald Reagan, Henry Kissinger and Walter Cronkite.

The fruits of failure. Olliemania is alive in Southern California. Iran-*Contra* Defendant Oliver North will be the star attraction this week at $1,000-a-plate fund raisers for Dana Rohrabacker and Christopher Cox, ultraconservative Republican congressional hopefuls who served with the former Marine in the White House. Still, a poll of North's popularity in Orange County should merit a raised eyebrow. "North got a 73% approval rating from voters here," gushed a Cox spokesman. "That's higher than the President's."

More failure, more fruits. Talk may be cheap, but Robert Bork isn't. The rejected Supreme Court nominee is reportedly raking in $12,000 a speech, and may earn $600,000 this year on the lecture circuit. Had he not been bearded in the Senate confirmation process, Bork would be making $104,100 on the high court.

Q: **What do Manuel Noriega and Bernhard Goetz have in common?**

A: **Their lawyer Barry Slotnick**

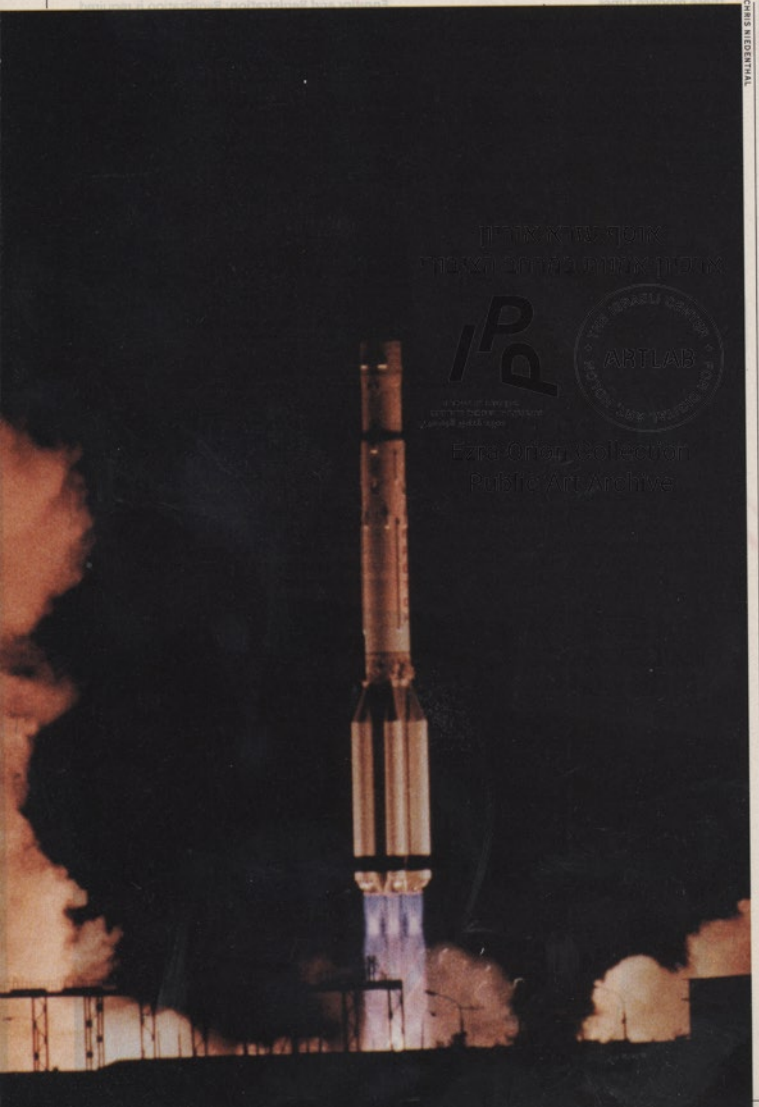
CARLOS GUARDIA—SIPA

J.P. DIEDERICH—CONTACT

Quote of the week. From White House Astrologer Joan Quigley: "To my certain knowledge, the President, the Secretary of State and the State Department together agreed with the Russians when the summit would be held. I had absolutely nothing to do with it."

Onward to Mars

A dramatic launch heralds a new era of missions to the Red Planet



CHRIS NIEDENTHAL

From the Kennedy Space Center and the Soviet Union's Baikonur Cosmodrome, powerful shuttles and unmanned rockets lift off week after week, bearing construction modules and fuel supplies to a giant space station in earth orbit. There, skilled workers have been assembling the ship that will take the first humans to Mars. After more than a year of construction, the million-pound, ungainly looking spacecraft is ready. With a crew of eight, it separates from the space station and heads for Mars, following the Hohmann ellipse, a space trajectory that may one day be as familiar as a great-circle route over the North Atlantic.

Twenty days later, the blue-white earth has shrunk to a bright dot of light against the background of stars in the eternal night of outer space. Looking back, the crew members are filled with a sense of isolation, a feeling that will never quite leave them during the 280-day outbound leg of their journey. A busy schedule provides some distraction. The space travelers perform scientific experiments, practice taking shelter against solar-flare radiation, tend vegetables in their hydroponic greenhouses, exercise vigorously for several hours each day and tap into digital libraries for music, light reading matter and courses in Martian meteorology and geology.

At first they are able to communicate easily with controllers on earth. But as they head farther into space, the time required for their radio signals to reach earth lengthens to minutes, and the ever widening gap between questions and answers makes conversation difficult. Now, with the earth more than 100 million miles away, Mars is looming in the spacecraft portholes, and the crew begins preparing for a yearlong adventure on another world.

A manned trip to Mars, long the stuff of science fiction, now appears to be just a matter of time. The mystic planet, glowing red and ever brighter in the night skies, is heading toward its closest approach to the earth in 17 years this September, tantalizingly near and beckoning. After a hiatus of a dozen years, during which neither the U.S. nor the Soviet Union mounted missions to Mars, a spacecraft is once again

Lifting off from Baikonur, the unmanned Phobos probe begins its seven-month journey

on its way, opening a new era in the exploration of the earth's closest planetary neighbor. During the next decade or so, the Soviets will launch a series of increasingly sophisticated unmanned Mars probes that they hope will culminate in a joint U.S.-Soviet manned mission to the Red Planet by the year 2010.

Last week that trip moved a step closer to reality. From its launching pad at the Baikonur space complex, near Tyuratam in the Soviet republic of Kazakhstan, a Proton rocket carrying an unmanned spacecraft rose on an orange and blue column of fire that illuminated the night sky. Turning lazily eastward, the rocket sent the craft off on an ambitious mission: to scout Mars and probe Phobos, one of its two tiny moons. Far below at the sprawling complex, technicians swarmed over a sister ship that is scheduled to be launched this week on a similar mission. Exulted Roald Sagdeyev, director of the Soviet Space Research Institute: "Now we can go and drink champagne!"

Even as the celebration went on, the thoughts of space experts turned to future Mars odysseys. Scientists and engineers in both the U.S. and the Soviet Union are involved in the design of complex unmanned craft that will travel to the planet. Some American scientists are even conducting tests on a model of the robotic vehicle that may one day rove the Martian surface. Others are considering the ships that will carry human crews to Mars, the orbiting space station needed to launch them, the size and safety of the crews and the most practical routes through space. Though some formidable problems remain, many Soviet and U.S. experts see no insurmountable obstacles to landing humans on Mars early in the 21st century.

While the American space program has been crippled since the *Challenger* disaster in January 1986, Soviet cosmonauts have been gaining invaluable experience aboard the orbiting Salyut and Mir space stations. And though U.S. astronauts are scheduled to return to space this September in the shuttle *Discovery*, which was wheeled to its Kennedy Space Center launching pad last week, NASA Administrator James Fletcher concedes that the Soviets are now "way ahead of us in manned flight." If each nation goes its own way, he predicts, the Soviets could land humans on Mars at least five years before the U.S. could.

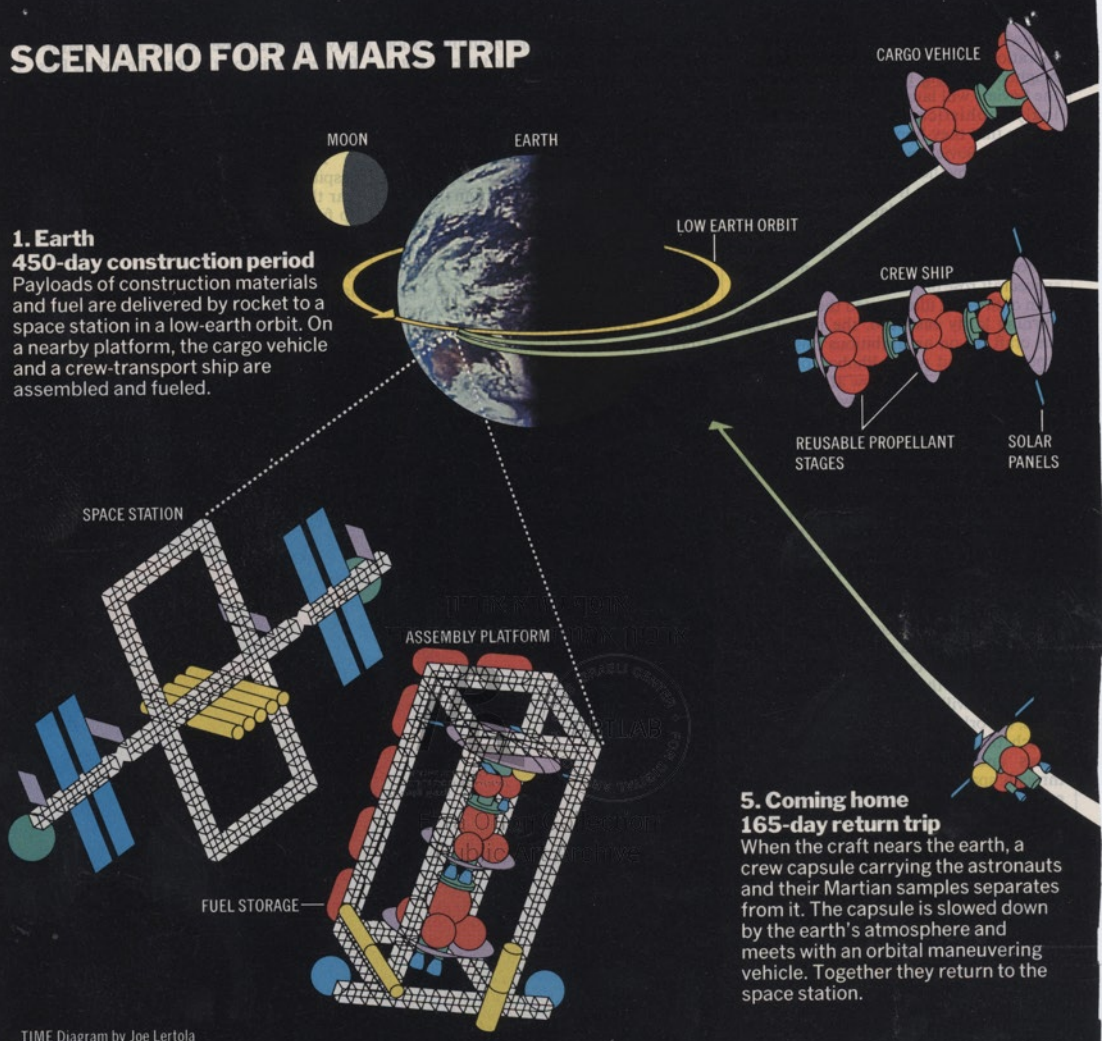
Stifled by budget cuts and foundering without clear-cut goals, NASA has scheduled only one Mars probe, the Mars Observer, which will go into orbit around the planet in 1993 to collect data on climate and geology. And while President Reagan agreed at the recent Moscow summit to a cautious joint communiqué describing "scientific missions to the moon and Mars" as "areas of possible bilateral and international cooperation," the Administration has been at best lukewarm to the concept of exploring Mars, jointly or otherwise.

Among other Americans, however, the idea of a manned Mars mission is gaining momentum, despite the estimated $100 billion price tag for the undertaking. The venture has been endorsed by a dozen major publications, ranging from the New York *Times* to the *New Republic*. In a recent full-page advertisement in the Washington *Post*, the 125,000-member Planetary Society urged support for a manned mission. The ad listed the names of a glittering array of such prominent Americans as Walter Cronkite, Jimmy Carter, Utah Senator Jake Garn, Nobel Laureate Physicist Hans Bethe and Notre Dame's former president, the Rev. Theodore Hesburgh. All of them have signed the Society's "Mars Declaration," which advocates a U.S. space program that would lead to the human exploration of Mars.

In Congress, too, support is growing, despite strong opposition from those who fear that a manned Mars trip would soak up funds needed for social programs, unmanned scientific space probes and military projects, among other things. Democratic Senator Spark Matsunaga of Hawaii has even written a book, *The Mars Project*, that strongly advocates the space journey.

While the U.S. space program languishes, scientists from twelve European

Hovering over the Martian moonlet, the craft will zap the surface with a laser beam

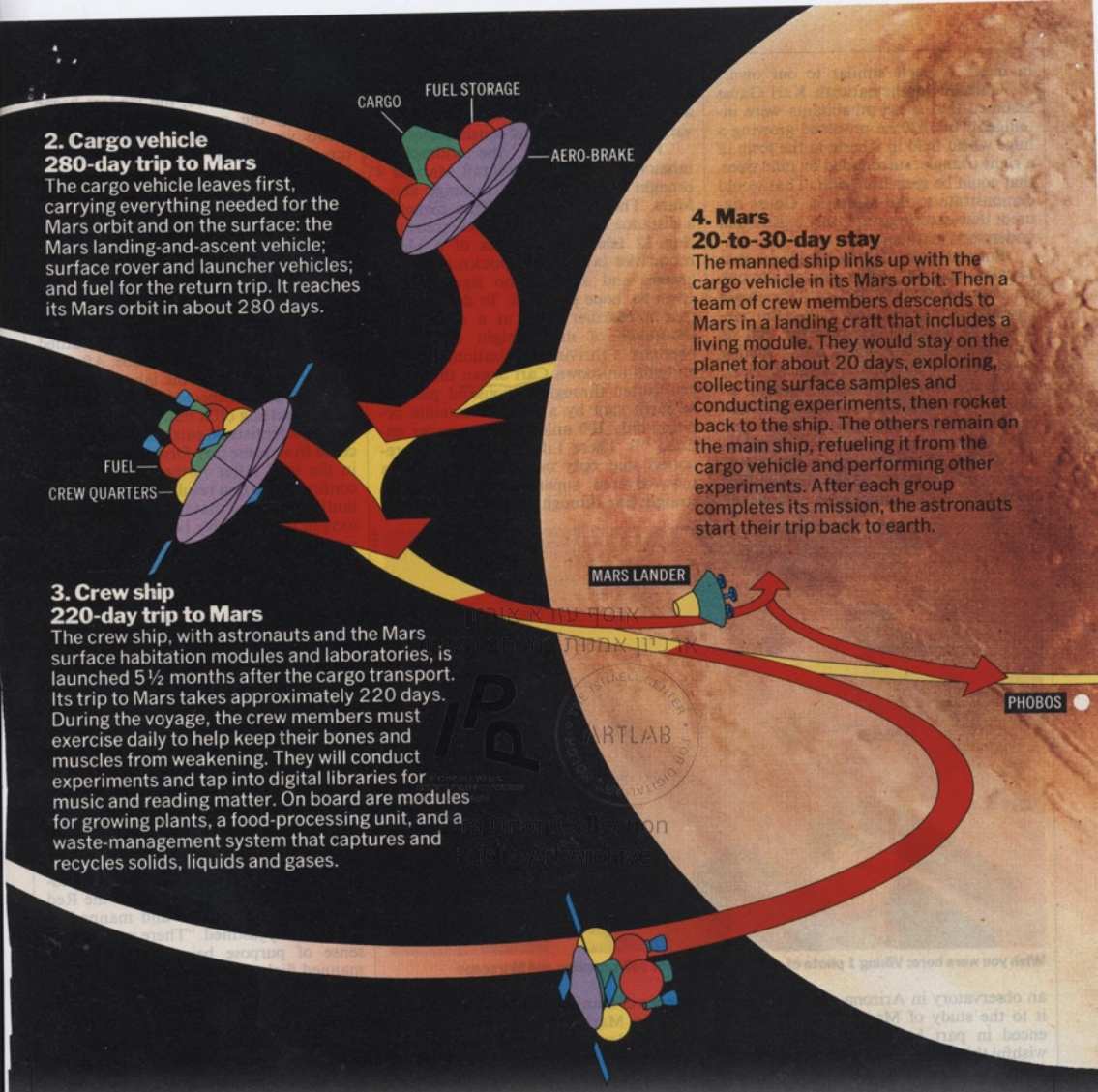


nations, the European Space Agency and the U.S. are participating in the Phobos mission, contributing technical expertise, instrumentation and onboard experiments to the Mars-bound ships. The U.S. is lending a hand with its superior Deep Space Tracking Network, which will aid the Soviets in navigating and keeping tabs on their craft. Another U.S. contribution, aboard one of the Phobos probes: a plaque honoring Astronomer Asaph Hall of the U.S. Naval Observatory, who in 1877 discovered Phobos and the other little Martian moon, Deimos (both named after the sons of the Greek god of war, and meaning fear and terror).

U.S. space watchers are impressed by the boldness, originality and scope of the Phobos operation. The twin Soviet probes will arrive at Mars in January 1989, easing into orbit about 4,000 miles above the planet's surface, or 140 miles higher than the orbit of Phobos. For four months the two probes will circle Mars in various orbits, peering down at possible future landing sites and using remote-sensing devices to investigate the landscape and weather.

Their scrutiny of Mars completed, first one probe and then the other will be sent by controllers to rendezvous with potato-shaped Phobos, which, like Deimos, is believed to be an errant asteroid that was captured by Martian gravity. Each craft, in turn, will descend as low as 100 ft. above Phobos. Maneuvering like cruise missiles, they will follow the contours of the landscape as their television cameras pick out surface features.

All the while, the versatile craft will be analyzing the composition of Phobos with two Buck Rogers–like devices. One, a laser beam only a millimeter in diameter, will vaporize first one spot and then another on the tiny moon, which is only 17 miles at its widest point, while an onboard instrument determines the chemical makeup of the vapor spewing up from each spot. Another beam consisting of krypton ions will bombard the moonlet, and an onboard mass spectrometer will identify the ions given off by the blasted surface materials.



Eventually each of the probes will release a lander that will rocket down onto the moonlet and shoot an attached "penetrator" into the surface as an anchor, essential because of the weak gravity (one-thousandth of the earth's gravitational pull). The solar-powered landers will then radio directly back to earth data on changes in the moon's gravitational field, thermal expansion and seismic noise. As if that were not enough, the frenetic probes will each drop a two-legged, domed "hopper" onto Phobos. After examining surface material and searching for magnetic fields at their landing sites, the hoppers will draw up spring-loaded, metal-alloy legs and, like giant frogs, leap about 20 yards to a new location, where the observations will be repeated. Each hopper is expected to make about ten leaps, reporting back each time by radio, until its battery runs out.

"These missions are novel and trailblazing," says Cornell University Astronomer Carl Sagan, president of the Planetary Society and the man who first proposed a joint manned mission to Mars. "In terms of science, we'll all find out a lot about Phobos." Furthermore, he says, "in the long run, Phobos could act as a staging platform for human missions to Mars. It could also be a place where humans could live and work while they control robotic explorers on the surface of Mars."

Ever since they first peered into the night skies, humans have been awed and intrigued by Mars' baleful red glare. Ancient civilizations bestowed on the planet the name of their god of war. It was named Ares by the Greeks, Mars by the Romans. When the first telescopes revealed that the planets were neither specks of light nor gods but worlds, perhaps like earth, the notion grew that Mars might harbor life. Noting variations between the bright and dark areas of the planet, British Astronomer Sir William Herschel in 1784 attributed them to "clouds and vapors" and concluded that Mars had an atmosphere and that "its inhabitants probably enjoy a situation

in many respects similar to our own."

German Mathematician Karl Gauss assumed that those inhabitants were intelligent. In 1820 he proposed growing a huge wheat field in Siberia in the form of a right triangle, surrounded by pine trees, that could be seen from afar. That would demonstrate to the Martians, Gauss figured, that earthlings not only existed but understood mathematics.

But was there any real evidence that Martians existed? After peering through his telescope in 1877, Italian Astronomer Giovanni Schiaparelli (an uncle of the celebrated Paris couturiere) reported that he had charted several dozen *canali* linking dark areas on the surface of Mars. These *canali*, the astronomer wrote, "present an indescribable simplicity and symmetry that cannot possibly be the work of chance."

No one was more excited by this revelation than a wealthy American mathematician, diplomat and astronomer, Percival Lowell of Boston, who established an observatory in Arizona and dedicated it to the study of Mars. By 1908, influenced in part by optical illusions and wishful thinking, Lowell had counted and named hundreds of canals, which he believed were part of a large network conveying water from the polar ice caps to the parched cities of an arid and dying planet. Lowell's observations and musings, in turn, inspired British novelist H.G. Wells to write *The War of the Worlds*, a dramatic account of an invasion of the earth by octopus-like Martians. In 1938 a radio adaptation of that novel by another man named Welles—Orson, that is—panicked many Americans who believed that a real Martian invasion was under way.

Even after the mighty 200-in. Mount Palomar telescope revealed no evidence at all of networks of straight lines or other manifestations of intelligent life on Mars, the fascination continued. Fredric Brown's novel *Martians, Go Home*, Ray Bradbury's *The Martian Chronicles*, Robert Heinlein's novel *Stranger in a Strange Land*, and the popular Buck Rogers comic strip all involved encounters with Martians of various sizes, shapes and consistencies.

Finally, in 1965, the triumphant mission of the U.S. spacecraft Mariner 4 brought some reality to musings about Mars. The craft flew past the planet at a distance of only 6,100 miles, transmitting 22 television pictures of a bleak, moonlike landscape, pockmarked by craters and showing no signs of life. Even so, hope persisted. To demonstrate that a Mariner flyby at a distance of thousands of miles might completely overlook a thriving civilization, a young and still unknown Carl Sagan that same year sifted through a thousand pictures of earth shot by a weather satellite orbiting only 300 miles up. In a paper entitled "Is There Life on Earth?" he reported that only one photograph, of a snow-covered superhighway cutting a straight line through a forest, showed any evidence of man's presence on this planet.

Wish you were here: Viking 1 photo of mechanical arm for soil sampling and Marscape

When Mariner 9 was successfully inserted into low orbit around Mars in 1971, a planet-wide dust storm obscured its vision for six weeks. After the dust settled, Mariner's cameras revealed a fascinating landscape: towering volcanoes, great canyons, lava flows and a multitude of craters in the red-hued plains. What excited scientists and Mars buffs the most, however, was the unmistakable traces of dry riverbeds and deltas etched into the rock, evidence that water had once flowed freely on the Martian surface. Had life evolved on Mars while water was still ample? And might living organisms still exist there, perhaps in microscopic form?

It was in part to answer such questions that the U.S. Viking 1 and 2 spacecraft, each consisting of an orbiter and a lander, were dispatched to Mars. When they arrived, 45 days apart, in 1976, cameras aboard the orbiters snapped away and remote-sensing devices searched for water vapor in the thin atmosphere and sought out frozen water in the polar ice caps. On the surface, the landers began providing the most accurate measurements yet of Martian surface temperatures, atmospheric density and wind velocity, while the cameras shot more than 4,500 spectacular close-up pictures of the surrounding, rock-strewn landscape. Each lander was also equipped with an arm that scooped up soil samples and fed them to a little onboard biological laboratory, where they were analyzed for any signs of metabolic activity, which would signify life.

The first soil sample briefly breathed new life into the Mars mystique. After being moistened inside the lab, it suddenly released an unexpectedly high burst of oxygen, setting off a flurry of speculation among scientists on earth. Did the oxygen come from some tiny form of Martian life in the soil? After further tests failed to confirm those first results, scientists reluctantly concluded that the large amount of oxygen had probably been produced by a simple chemical reaction between water vapor and some unidentified oxygen-rich compound in the soil sample.

Some scientists, Soviet and American alike, have still not abandoned hope of finding life or its remnants deeper in the Martian soil. There life forms might have access to water and be protected from the fierce solar ultraviolet radiation that rains down on the surface, virtually unobstructed by the Martian atmosphere. Sedimentary rocks in the ancient riverbeds would be an ideal place to hunt for fossils of organisms that may have lived when Mars was more benign, with a thicker atmosphere, warmer climate and running water on its surface.

For these reasons alone, Mars enthusiasts say, further exploration of the Red Planet, both unmanned and manned, is scientifically justified. "There is a growing sense of purpose being attached to a manned flight to Mars, both in the Soviet Union and the U.S.," says Vyacheslav Balebanov, a deputy director of the Space Research Institute of the Soviet Academy of Sciences. Like most of his counterparts in the U.S., he would prefer a measured, logical, step-by-step program to a more hazardous, hastily mounted manned mission. "We must start to explore Mars in detail before such a flight is possible," he says.

That is just what the Soviets plan to do. In 1992, when America's Mars Observer is scheduled to fly, they hope to send a third Phobos spacecraft into Mars orbit carrying advanced remote-sensing devices, including a radar mapper that will seek out the best landing sites for future missions. Two years later, the Soviets intend to launch a pair of highly sophisticated landers to Mars. Each will carry a small computer-controlled surface rover, a six-wheeled vehicle capable of traveling as far as 60 miles from the lander. It will be equipped with TV cameras, scoops and drills to sample materials and a minilab to analyze them. With information gained

from this mission, the Soviets hope to launch as early as 1998 a larger Mars lander-rover that could return soil samples to earth.

While the U.S. lacks a strong commitment to sending humans to Mars, the Administration's space policy, announced by President Reagan in February, does envision eventual "human exploration of the solar system." Toward that end, NASA has launched Project Pathfinder, a program to develop 18 new space technologies. They include compact nuclear reactors for powering lunar or Martian bases, in-space construction and assembly of spacecraft, and orbiting fuel depots for moon and Mars ships. "You can talk about going to Mars," says Pathfinder Leader Robert Rosen, "but you can't do it without these technologies." Congress appropriated $40 million for the project's first year.

Congress. "The station would be needed to serve as an assembly point," says NASA's Brian Pritchard, who has studied the feasibility of such a plan. "We don't have the power to lift from 1 million to 3 million lbs. [the weight of the Mars ship] into orbit from the earth."

Why so huge a craft? In addition to carrying a million or more pounds of fuel, the ship must accommodate and sustain human beings for as long as three years. Just to exist in space for one day, for example, each crew member will require several pounds of oxygen, 4 lbs. of water and 3 lbs. of food. Consequently, for a crew of eight on a 900-day mission, a Mars spacecraft would have to carry as much as 40 tons of provisions alone. Any added weight would require using—and carrying—even more fuel, both for pulling away from the earth and launching from Mars for the return trip.

ing to develop what they call a "self-contained bioregenerative support system." It will include a chamber for growing plants; a food-processing module for extracting the maximum edible content from all plant parts; and waste management modules for capturing and recycling the solids, liquids and gases necessary to support life on a space journey.

In most of the manned Mars scenarios envisioned by NASA planners, the spacecraft would be constructed and fueled at a space station orbiting the earth at 17,500 m.p.h. Compared with blasting off from earth, considerably less fuel is needed to launch the craft from this speeding platform and boost it toward Mars at a velocity perhaps as great as 50,000 m.p.h. At that velocity, says Space Consultant and Author James Oberg, the "earth's gravity pulls on you a little, but it's like brushing your way through cobwebs." Following

A Profile of Mars

Diameter. 4,200 miles, in contrast to 7,926 miles for earth.
Gravity. 38% as strong as earth's.
Atmosphere. About 1% as dense as earth's; largely carbon dioxide with small amounts of nitrogen and argon.
Climate. Temperatures from −225° F to 63° F.
Topology. Craters, extinct volcanoes, enormous rift valleys and basaltic lava flows.
Distance from earth. At the closest, 35 million miles.
Tourist attractions. Olympus Mons, a volcano nearly 16 miles high, and Valles Marineris, a canyon system 2,500 miles long.

OLYMPUS MONS

NASA

Pathfinder did not start from scratch. NASA and the aerospace industry have long planned a variety of Mars missions that could lead to a manned flight. At NASA's Jet Propulsion Laboratory in Pasadena, Calif., scientists are designing an unmanned rover with six wheels, each more than 3 ft. in diameter, to accommodate the rocky Martian terrain. In a still unapproved mission, the rover, imbued with artificial intelligence and television eyes, would seek out appropriate rock samples and stow them in a craft designed to return them to earth for analysis. At NASA's Marshall Space Flight Center in Huntsville, Ala., experts are designing living quarters for the space station that the U.S. hopes to begin assembling in earth orbit in the mid-1990s. Plans call for private sleeping cubicles, each equipped with a TV, sound systems and a computer. Mars enthusiasts point out that approval of a manned Mars mission as a goal would finally provide a compelling rationale for the projected $30 billion space station that NASA has had trouble selling to a reluctant

There is an alternative to a fully stocked larder: recycling, the recovery of water and oxygen from waste products. NASA has developed prototypes for reclaiming pure water from urine and wash water, and oxygen from the carbon dioxide exhaled by astronauts. For their part, the Soviets have been retrieving some of their water for years, condensing it from the exhaled, humid air in the spacecraft. But Arkadi Ushakov, of the Soviet Academy of Sciences, concedes that the recovery systems in use today cannot meet the demands of two- or three-year missions. He believes a Mars ship will have to contain its own biosphere of renewable plant and water resources.

Toward that goal, Soviet researchers are investigating natural recovery systems: plants that will not only serve as food but also, in the process of metabolizing, absorb carbon dioxide and produce oxygen. The best performers so far, Ushakov says, are traditional food plants like carrots, sugar beets and salad greens. At the Kennedy Space Center, NASA scientists are try-

the path of the Hohmann ellipse,* the craft would coast in a leisurely course halfway around the sun, then begin to accelerate as it came under the gravitational sway of Mars.

To save fuel that would otherwise be used by firing retrorockets to ease the ship into orbit around Mars, the craft will be equipped with an aerobrake. This saucer-shaped structure, as large as 80 ft. in diameter, will slow the craft as it encounters the thin Martian atmosphere. A short burst from the rockets will then boost the craft just above the atmosphere and into orbit. From the orbiting craft, part of the crew will descend to the surface in a lander. After piling sand on the vehicle to shield it from the radiation that bombards the Martian surface, they will use the lander as a base for exploration.

How long the voyagers stay on Mars will depend in part on the homeward-

*The Hohmann ellipse is an ideal trajectory requiring a minimum of energy for a journey between any two planets, named after the German engineer who calculated it in 1925.

bound route. To await the proper alignment of Mars and the earth for an economical Hohmann-ellipse return, the crew would have to remain on Mars for more than a year—increasing the mission length to what now seems an unbearably long 1,100 days. But with the expenditure of more fuel, the explorers could blast off earlier, head toward Venus and loop around it, using the planet's gravity to whip their craft toward earth at a higher speed. That would cut the mission time to 600 to 700 days.

But the Venus route would also cause the craft to re-enter the earth's atmosphere at 80,000 m.p.h., in contrast to the returning Apollo's 25,000 m.p.h. "We're not sure we know how to build the appropriate heat shields," says Oberg. Also, at that speed, the astronauts would have a much smaller "window" for re-entering the atmosphere. "Come in too low, and you burn up," says Oberg. "Come in too high, and you overshoot. You miss the earth, and you'll never see it again." Other plans call for an unmanned cargo ship to precede the manned craft to Mars and for even higher velocities that would cut mission times down to a year.

Yet the problems of sending a spacecraft to Mars and bringing it back to earth pale when compared with the challenge of keeping its human cargo safe and in peak physical and mental condition. The medical consequences of long periods of weightlessness are still not fully understood. And radiation, says NASA's Michael Bungo, "is going to be a showstopper." Once beyond the earth's atmosphere and magnetic field, which protects terrestrial life from most lethal radiation, crew members would be vulnerable to cosmic rays. These highly energetic particles travel through space at close to the speed of light and can produce hazardous secondary radiation when they strike atoms in the aluminum walls of a spacecraft. During a single Mars mission, says Frank Sulzman, chief of NASA's space-medicine and biology branch, unprotected astronauts could receive an unacceptably high dose of radiation—more than is now allowed workers in a lifetime on jobs that expose them to radioactivity.

Even more dangerous are solar flares, which usually blossom on the sun around the peak of the eleven-year solar cycle. During these massive explosions, which astronomers can spot in the form of extra-bright splotches suddenly appearing on the sun, bursts of X rays and charged particles are hurled outward at high velocities. Because protons from a large flare can easily penetrate the walls of a spacecraft and fatally riddle the body of an astronaut in half an hour, planners envision an onboard shelter into which the crew could repair as soon as a solar-flare warning was sounded. One idea is to build the shelter with the heavy-walled oxygen and

The Perils of Zero Gravity

As imposing as the problems of extended space flight seem, most experts are confident that humans can survive the journey to Mars. But in what shape will they be when they get there? Says NASA Physicist Wendell Mendell: "It doesn't do you much good to deliver a human to the Martian surface if that human is inert for a time after landing."

Despite the experience gained from Apollo moon shots and the longer Skylab missions, U.S. doctors have some doubts about the ability of humans to withstand the effects not only of prolonged weightlessness but also of the transitions from gravity on earth (one G) to zero G in space to 0.38 G on Mars. "We're nowhere near ready to send a human to Mars," says Dr. Michael Bungo, director of NASA's Space Biomedical Research Institute at the Johnson Space Center. "We've got years more of basic research to do."

Soviet space doctors seem more sanguine. While no American has stayed in space for more than three months, the Soviets have repeatedly staged manned flights of longer duration, capped by the 326-day stay of Cosmonaut Yuri Romanenko last year aboard the orbiting space station Mir. "The experience of that flight," says Dr. Arkadi Ushakov of the Soviet Academy of Sciences, "testifies that we should be optimistic about long-duration space flight. Our knowledge in the field of weightlessness is growing, and we are learning what countermeasures need to be taken to ensure health and safety."

Ushakov believes that two effects of prolonged weightlessness, calcium loss in bones and muscle atrophy, can be largely prevented by exercise. A strict regimen on a treadmill helped keep Romanenko's muscle tone and reduced the calcium loss to a degree that Ushakov calls insignificant. But other effects attributed to weightlessness are still cause for concern. "There is a general weakening of the immune system in a long-duration flight," Ushakov says. "When this happens, there is a danger that every microorganism present in the ship can cause infection."

Zero gravity check-up: visiting the doc aboard Skylab

The Soviets have also detected changes in metabolic rates, which they say accelerate arteriosclerosis. Then there is the problem of neuromuscular control. Cosmonauts returning to earth after long flights have had trouble performing simple tasks like throwing a ball. Arriving on Mars, space travelers might be unable to carry out assignments.

The solution, many scientists believe, is to impart artificial gravity—in the form of centrifugal force—to the spacecraft. This might be accomplished by spinning a very large craft around its own axis. Other schemes envision three ships hooked together in a cartwheel-like arrangement that makes three revolutions per minute, or two vehicles attached by a half-mile-long tether rotating through space as the entire system speeds toward Mars. Still another idea is to schedule a daily workout for each crew member inside an on-board centrifuge, where resisting the centrifugal force would simulate working in gravity.

Apollo 11 Astronaut Michael Collins foresees some technical difficulties in such simulation. "Spinning wouldn't take that much power," he says. "But it still complicates things immeasurably from an engineering point of view." He notes that imparting spin to a Mars-bound craft could make both navigation and communication more difficult.

Space Scientist Carol Stoker, at NASA's Ames Research Center in California, points out that there would be benefits of artificial gravity beyond the physiological ones. "Toilets would flush properly, things wouldn't float in the air, and just think of surgery in zero gravity," she muses. Malcolm Cohen, chief of the neuroscience branch at Ames, worries about the possible physiological effects of rotation. "Weightlessness is the devil we know," he says, "and we have some idea how to overcome its effects. But artificial gravity in space is a devil we don't know well." Still, he concludes, "it's certainly an option we can't reject."

water tanks that must be brought along anyway. Soviet scientists are experimenting with generating strong electrically charged fields around the spacecraft. These would have an effect similar to that of the earth's magnetic field, deflecting the speeding particles around the ship.

Another possible hazard on a long space journey has its source on planet earth: human nature. Soviet flights have demonstrated that performance levels begin to decrease as the days stretch into months. Cosmonaut Yuri Romanenko, whose 326 days aboard the space station Mir set a space endurance record last year, was down to only two hours of productive work a day toward the end of his eleven-month flight and had become decidedly peevish. "Leave me alone," he once snapped to mission control. "I have a lot of work to do."

Both American and Soviet behavioral scientists have begun to investigate small-group dynamics, which are likely to assume considerable significance during extended spaceflight. "There are always minor irritations involved in working with other people," says Psychologist Clay Foushee, of NASA's Ames Research Center. "Normally, these are not a problem because you can get up and move away. The trouble occurs when you can't leave a situation." That trouble can become catastrophic. Long Antarctic expeditions, which involve small groups isolated for months, have been marred by fights and occasional violence.

Other questions about group dynamics abound. Among the foremost: Should women be included on a Mars expedition? If so, what about sex? No one likes to talk publicly about that, admits NASA Flight Surgeon Patricia Santy. "There's no reason, even in a highly motivated professional crew, that the same kind of sexual tensions that develop here in offices aren't going to develop in space." Santy believes women should be included in the crew. If they are, she says, there should be at least two—both for mutual support and to avoid disruptive sexual entanglements aloft. Former Astronaut Michael Collins has suggested an even simpler remedy: send up a crew of four married couples. "But eight is a bad number," he concedes, "because you want an odd number; in arguments, you don't want to risk a 4-to-4 tie vote."

For all the enthusiastic talk about a manned mission to Mars, many influential voices have been raised against it. None is more formidable than that of University of Iowa Physicist James Van Allen, the discoverer in 1958 of the earth-girdling radiation belts that today bear his name. With other scientists, he has long been critical of the shuttle, the space station and other programs that draw funds away from space science. "Any serious talk of a manned Mars mission at this time is grossly inappropriate," he says, arguing that the top priority of the U.S. should be to develop and build expendable rockets to launch satellites and space probes. "To talk about manned missions to Mars when we can't even launch a 500-lb. satellite is totally off the wall."

Van Allen believes a manned Mars mission would be "monstrously" expensive, further draining money from more economical unmanned scientific probes. The Mars mission does have a certain appeal, he concedes, because "it's a matter of high adventure. But if you want to put it on any practical basis, it's totally uncompetitive with unmanned spacecraft by a factor of ten."

ALAN OXLEY-COMPIX

High hopes: the shuttle *Discovery* on the launch pad in Florida

Will the U.S. program ever lead to a manned flight to Mars?

The idea of a joint U.S.-Soviet Mars mission is galling to other Americans who, *glasnost* notwithstanding, simply do not trust the Soviets. Their view was summarized in a recent op-ed piece in the Los Angeles *Times* by Space Writer Alcestis Oberg, the wife of James Oberg. "A joint mission," she wrote, "completely and utterly ignores reality." Among the concerns raised by the proposed mission, she wrote, are the "potential for spying, for technology transfer, for interference in our political system, for the 'hostage holding' effect it would have on our space program and on our future." Her conclusion: "A complex, expensive, 25-year-long joint research program is like a marriage. It should be entered into soberly, advisedly, for better or for worse—and only after a very long engagement during which trust is built and loyalty tested."

Even proponents believe the U.S. should approach a joint effort with the Soviets in gradual steps, perhaps starting with an unmanned mission to bring back soil samples from Mars in 1998. Many, like Sagan, are convinced that the advantages of a cooperative mission would override the possible risks. Besides sharply reducing the enormous costs of going to Mars alone, such a venture, says Sagan, "would revitalize a dispirited and unraveling NASA" and provide a "coherent focus for the U.S. space program."

Even more important, in his view, a joint mission might help draw the U.S. and the Soviet Union closer together. He dismisses fears that such a mission would risk giving away U.S. technology to the Soviets, pointing out that the Soviets are a decade ahead of the U.S. in several areas of spaceflight. "Technology transfer," Sagan concludes, "is likely to flow both ways."

The rising sentiment in the U.S. to return to space and eventually send men to Mars has not escaped the attention of politicians, including presidential candidates. Says Democratic Contender Michael Dukakis: "We should explore with the Soviet Union and other nations the feasibility and practicality of joint space-engineering activities that might pave the way to a joint manned mission to Mars." In a Huntsville, Ala., speech, Vice President George Bush urged a "long-term commitment to manned and unmanned exploration of the solar system. There is much to be done—further exploration of the moon, a mission to Mars . . ."

If the U.S. is to mount or even play a meaningful role in a manned Mars mission early in the 21st century, the next President will have to make a commitment to a coherent national space policy sooner rather than later. Enormous problems remain to be solved, and two decades is precious little time for developing a program that would land humans on another planet. The clock is running, and to NASA Ames Scientist Carol Stoker, the message from the Soviets is coming across loud and clear: "We're going to Mars, and the bus is leaving." And like her, more and more Americans are asking: Will the U.S. be aboard? ***—By Leon Jaroff. Reported by Glenn Garelik/Washington, J. Madeleine Nash/Pasadena and Richard Woodbury/Houston***

Revolution In Euro-TV

A smorgasbord of programs—and worries

S.E.T./Texto Press; Rex Features; NBC; Gallarde—Gamma/Liaison; Memory Shop; Morandi—Lucky Star/Dossier

What wonders are flickering on the small screens of Western Europe? What exotic images are radiating into living rooms from Stockholm to Salerno? Let's see . . . On a summer evening in Madrid, on Channel TVE-1 the American cops of *Hill Street Blues* trade quips in Spanish. In Paris U.S. Rocker Cyndi Lauper squeaks out a hit on the M6 channel. In Olso's Storting, the parliament building, news headlines flash on from Atlanta via Cable News Network (CNN), while in Italy Telemontecarlo offers viewers a romantic Brazilian mini-series called *Gabriela*. On West Berlin cable outlets, Britain's *Spitting Image* puppets deliver political gibes, while British BBC-1 viewers are riveted to the hilarious antics of teenagers and their parents in *Neighbours*, an Australian soap opera.

Five years ago, most West European viewers could not have imagined the international smorgasbord of programs that would soon materialize in their homes. For decades, they had subsisted on a diet of nationally produced news, arts and entertainment shows, spiced with a bit of *Dallas* or *Dynasty* and served up by what amounted to government-run monopolies. No longer—and on a number of counts. Advances in technology, trends in consumer demand and the unstoppable energies of a handful of international media moguls have burst the barriers of government control and revolutionized Europe's TV marketplace.

Three satellites beam the offerings of 33 channels, at least half of them financed by advertising, into Western Europe. Another six sky birds are scheduled to go into orbit by 1990. The installation of cable TV systems is moving forward on a broad front, while regular broadcast channels are increasing in number. Viewers cannot seem to get enough TV.

In its rapid and sometimes confusing growth, the privatization of West European television has created political, economic and cultural resonances. Proponents of private TV envision a web of multinational programs that will unite Europe in new—not to mention lucrative—ways. "The future of television," says Silvio Berlusconi, the Milanese video visionary who has TV and film interests in France, Italy, Spain and West Germany, "is that anyone will be able to watch anything."

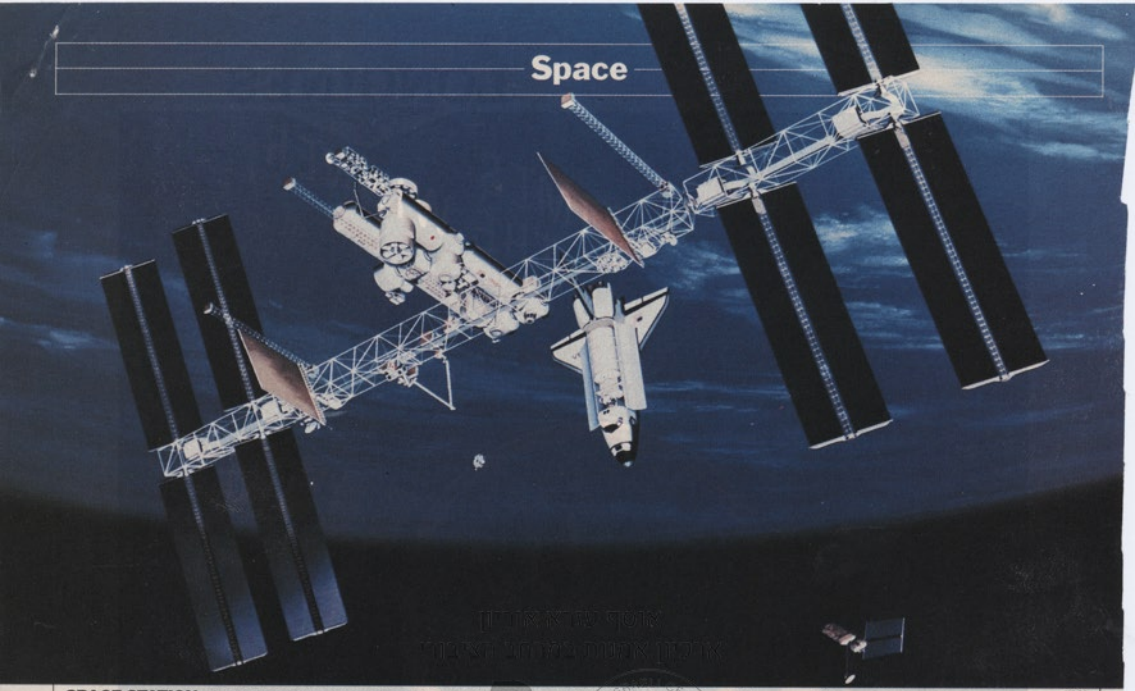
Critics of television deregulation, on the other hand, fear precisely that: wall-to-wall *Dallas*. They foresee a wave of mindless game shows, violent car chases and mind-numbing commercials—many of them imports from the U.S.—that will create a video wasteland, subsuming national interests, preoccupations, even languages. Among the critics is France's recently reappointed Minister of Culture, Jack Lang, who has emerged as one of Europe's most prominent spokesmen warning against U.S. "cultural imperialism." In confronting those and similar concerns, many countries are beginning to fine-tune the very notion and content of European television.

Britain is a prime illustration of Euro-television's profound changes. Considered the model of public service broadcasting, and eventually copied elsewhere in Western Europe, the British Broadcasting Corp. was formed in 1927 to regulate radio content. It is a public corporation, answerable ultimately to Parliament. The BBC held the television monopoly in Britain until 1954, when a Conservative government countenanced the Independent Television Network, a strictly regulated form of private television funded by advertising rather than TV license fees. The ITV channel provides diverse programming for audiences in 14 regions of Britain.

In 1982 Britain added commercial Channel 4 to serve ethnic and upper-middlebrow cultural interests. By the end of this year, the Conservative government of Prime Minister Margaret Thatcher is expected to authorize a fifth channel, funded either by advertising or subscription. As it is, Britain's noncable viewers are among Europe's best served, with homemade choices ranging from thrillers like *Edge of Darkness* to *Gardeners' World*, a video school for 3.5 million British green thumbers.

Since 1985 France has doubled its number of channels, from three to six; four are privately owned. That leaves three West European countries without access to private TV: Greece, Portugal and Spain. All will probably be along. Last April the Spanish parliament approved the creation of three private channels to compete with three state-run services. Portugal is considering the issue, while pressure for privatization is mounting in Greece.

One of the major forces behind the television explosion has been the proliferation of cable TV. Some 12.8 million of the 130 million homes in Western Europe subscribe to cable. According to London-based CIT Research, a media analysis firm, that number should double by the year 2000. Holland and Belgium, with their concentrated populations, are already 90% cabled. Viewers there and in West Germany can switch on major soccer matches, business and financial shows, films from East bloc countries and local political interview shows. About 256,000 British households taking cable can receive up to 30 channels. One of the beneficiaries of the trend is British-based Sky Channel, controlled since 1983 by Media Baron Rupert Murdoch. It beams a lineup laden with such worn U.S. reruns as *The*



SPACE STATION: the U.S. needs platforms in orbit, but the proposed Freedom, shown above, is too grandiose and lacks a clear purpose NASA

The Next Giant Leap for Mankind

Two decades after its first moon landing, it is time for the U.S. to head for Mars

BY MICHAEL D. LEMONICK

Three-quarters of a billion people peered at the murky images on their television screens on July 20, 1969, as Neil Armstrong became the first human to stand on another world. To Americans, the spirit-lifting achievement was well worth the cost and effort. The quest to reach the moon had revitalized U.S. science and technology and yielded countless benefits to industry and the military. Most amazing of all, the *Eagle* landed only eight years after John F. Kennedy proclaimed the moonshot a national priority.

But after Apollo, something went wrong with the nation's space program. Despite successes—such as the Skylab space station and the series of unmanned missions that will reach its climax next month when Voyager 2 arrives at Neptune—the program seemed to founder. The space shuttle, for example, was oversold as the one answer to U.S. space-transportation needs. But it is too big to put astronauts in space efficiently, too small to launch the largest payloads and too unreliable to live up to the 60-flight-per-year schedule once promised. The result, even before the *Challenger* accident: a backlog of unlaunched missions.

Now NASA is poised to make a similar mistake with its next major project, the $32 billion Freedom space station, scheduled to go into full operation in the late 1990s. Like the shuttle, it is being presented as a widely versatile project that will provide for the needs of scientists, engineers and space explorers. But without a focused, long-range program, those needs are not clear.

The crux of the problem is that the leadership Presidents Kennedy and Lyndon Johnson gave the Apollo program was not continued by their successors. That leadership gap may soon end, though. As early as this week, President George Bush is expected to announce his vision for the U.S. space program. No one knows what Bush will say, but some members of his National Space Council, chaired by Vice President Dan Quayle, reportedly favor a return to the moon, followed by a manned trip to Mars.

That would be ambitious and expensive—up to $150 billion. But the payback would be great. Such a specific, long-term goal would invigorate NASA. It would revive public interest in science, providing new pep for a sector of the educational system that has become disturbingly weak. It would stimulate innovation in everything from materials science to computers to communications. It would create jobs. And, least tangible but perhaps most important, it would add enormously to the nation's prestige.

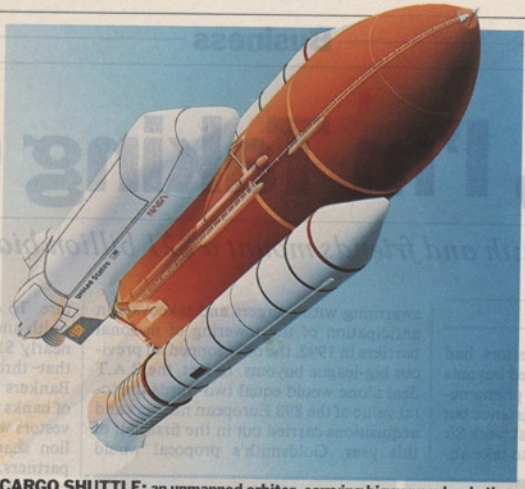
Moreover, points out Eugene Cernan, who walked on the moon in 1972, with such a long-range goal "we can then work backward and take the steps to get us there." That would eliminate the let's-build-it-and-see-what-it's-good-for approach. Far from withering, other space initiatives would be lifted by the rising tide of national interest and funding. Unmanned probes to the planets would continue, and NASA would still be able to launch the Mission to Planet Earth, a series of satellites designed to study the planet's environment and give scientists the information they need to head off ecological disaster.

The most reasonable date for a Mars mission is 2020. That allows plenty of time for a measured approach and

spreads the expenditure over a sensible period. It also gives NASA ample opportunity to choose the next goal after Mars—exploration of the asteroid belt, for example, or a manned trip to the outer planets. Robot probes would have to study the Red Planet in depth first. One, the Mars Observer, is scheduled for a 1992 launch, and others would have to follow.

Another logical stepping-stone is a lunar base, which could be built by 2000, as a testing ground for technologies necessary for a Martian sojourn. In particular, astronauts would experiment with living quarters in which air and water are recycled. Inhabitants of a lunar base would also begin learning how to mine the moon for raw materials, including trapped gases and minerals, that would permit the base to become almost entirely self-sufficient and thus permanent.

Before such a moon base can be built, NASA will have to get some kind of space station: the massive components needed for a lunar habitat are too heavy to lift from earth and will have to be assembled in space. The station will also be needed for assembling a bulky Mars vehicle and studying the effects of long-term space flight. But a single station may not be the best option. Several experts have suggested breaking it down into smaller units. One such station, the Industrial Space Facility, has already been designed by a Houston firm, Space Industries Inc. At $900 million, it could be launched by 1994 and take over most of the Freedom station's proposed experiments in space manufacturing. Another mini-station could handle biomedical studies, and others could be used as assembly and takeoff points for the Mars and subsequent missions. Just as with the moon base, these stations would operate indefinitely. Being smaller and less complicated than Freedom, the mini-stations could presumably be launched and built at a lower overall cost.



NASA

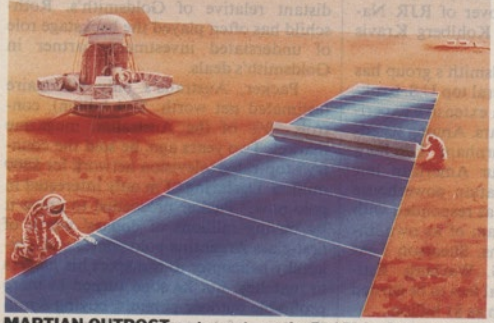
CARGO SHUTTLE: an unmanned orbiter, carrying bigger payloads than the manned version, will be a low-cost interim step to a heavy-lift booster

NASA and the Defense Department have already begun work on two new launchers to make space-station construction feasible. One is a heavy-lift unmanned rocket for massive payloads. The other is the National Aerospace Plane, or "Orient Express." Smaller than the shuttle, it would take off like an airplane from a runway, soar into space to deliver its human cargo, then return and land. And NASA has plans to convert the present shuttle into a cargo-only model, with a larger payload than the manned version. Together, these launchers would give NASA much needed flexibility.

The cost of such a multi-step project would be large—at least $5 billion a year and maybe considerably more. But unlike the $35 billion spent on the shuttle program, the expenditure would produce a return not just in prestige and technological leadership but also in the establishment of bases and stations that can be used for future space projects. In order to ease the costs, the U.S. should encourage as much participation as possible by foreign governments. The Soviets, Europeans and Japanese all have active space programs, and duplication of efforts will increasingly be seen as an unnecessary waste. Many countries are interested in participating in the Freedom project or Mission to Planet Earth or both, and the Soviets have accepted international help on their Mars probes.

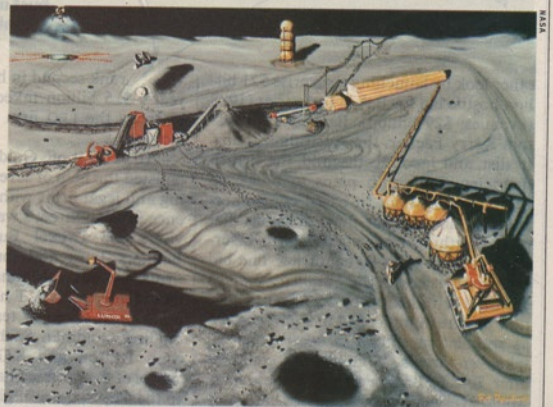
NASA's budget will have to be raised to pay for such an ambitious program, perhaps even doubled from its current $11 billion a year. That will be hard in an era of budget deficits. But there is support for a Mars mission in both the House and the Senate. If the President comes out strongly for the mission, Congress should be able to find a way to fund it. One option: to siphon the money from Star Wars and other questionable defense programs.

The U.S. cannot remain a leading force in technology, industry and science unless it is in the forefront of space exploration. Throughout its history, America has been a nation of discoverers and achievers. If it fails to take the next major step in space, it will have given up an essential part of its national character. *—Reported by Glenn Garelik/Washington and Richard Woodbury/Houston*



NASA

MARTIAN OUTPOST: astronauts on the Red Planet will probably have to find water and air in its soil and rocks and tap the sun's energy



NASA

LUNAR BASE: after serving as a test site for self-sufficient living, the

21/5/92

שגריר ארה"ב מותח ביקורת על חשאיות תוכניות החלל הישראליות

□ אבי בניהו

שגריר ארה"ב בישראל, וויליאם הרופ, מתח אתמול ביקורת על החשאיות המלווה את תכניות החלל הישראליות. לדבריו, חילופי המידע בין המדענים האמריקאיים והישראליים הם חד־צדדיים.

בהרצאה בפני חבר הנאמנים הבינלאומי של אוניברסיטת תל־אביב עמד השגריר על חשיבות חילופי המידע. "על מנת לקבוע היכן ישנה התאמה טובה בין היכולות של ארה"ב וישראל בפעילות העתידה בחלל צריכה ישראל לדעת ככל שניתן על תוכנית החלל האמריקאית וארה"ב צריכה לדעת ככל שניתן על תוכנית החלל הישראלית. רק לאחר שמידע זורם באופן חופשי, הלוך ושוב, ניתן להגיע להחלטות אינטליגנטיות. אני מאיץ באחראים על חקר החלל הישראלי ובמדעני החלל להגביר את הדיאלוג עם בני שיחם האמריקאים. יש לי רושם שעד כה חילופים אלה הם חד־צדדיים יותר מדי," אמר.

פרופ' יעקב ישי, מהפקולטה לרפואה ע"ש סאקלר באוניברסיטת תל־אביב, תיאר את תוכנית האוניברסיטה והתעשייה האווירית לשלוח צרעות במעבורת האמריקאית שתשוגר באוגוסט או בספטמבר. מחזור חיים של צרעות נמשך כ־30 יום ועל־ידי שליחתם לחלל מקווים החוקרים ללמוד על השינויים החלים בבעלי־חיים. מחקרים אלה עשויים ללמד על הצפוי לאדם אם יישלח למסעות ארוכים לכוכבי לכת אחרים.

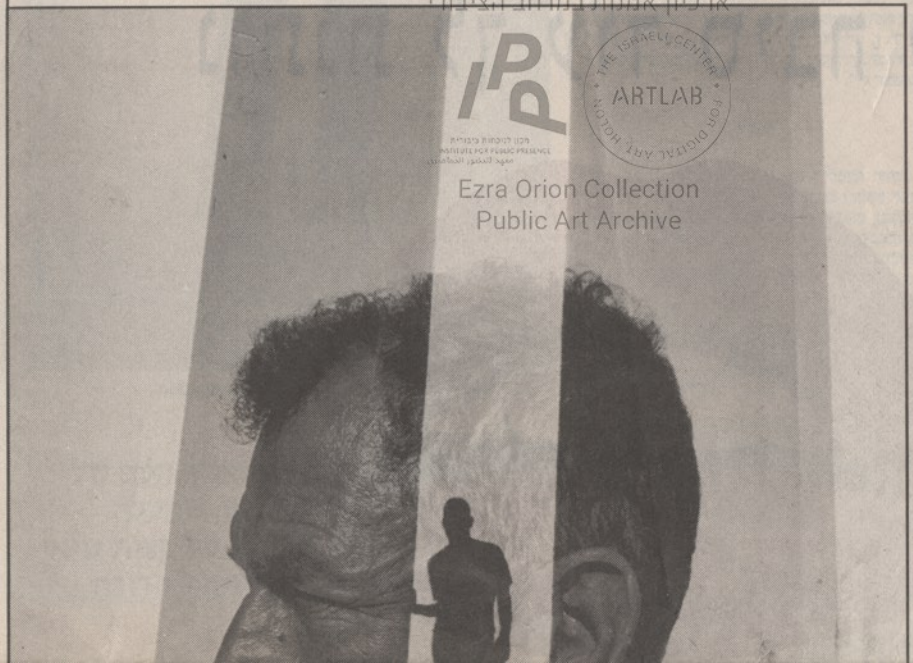
תוכנית נוספת שהוצגה בכנס עוסקת במשלוח טלסקופ אולטרה־סגול לחלל. מרכז התוכנית, ד"ר נח ברוש, אמר, כי הטלסקופ ישוגר בחללית רב־לאומית מפלטפורמה רוסית. באמצעות הטלסקופ ניתן יהיה למפות גלקסיות אחריות, קווזרים וכוכבים מסוגים שונים וללמוד על תהליכים שקרו וקורים ביקום. הטלסקופ נבנה על־ידי אל־אופ.

בתוכניות אלה יושקעו 10.5 מיליון דולר, מסר פרופ' עקיבא בר־נון, ראש סוכנות החלל הישראלית.

האסטרונאוט האמריקאי, פרופ' וויליאם טורנטון, שהשתתף בדיון, אמר, כי ניתן לעסוק במחקרי חלל גם במדינות קטנות בעלות תקציבים מצומצמים. לעיתים יש בכך יתרון, כי אז המכשור שהם מפתחים הוא קטן וקל. המחקרים המוצגים על־ידי אוניברסיטת תל־אביב הם דוגמא לכך, אמר.

מלחמת הכוכבים של עזרא אוריון

אוסף עזרא אוריון
ארכיון אמנות במרחב הציבורי



עזרא אוריון. ברקע, 'פסל זהות לירושלים', מעין כוכשיגור אנכי, מיועד גם לילדי הפעוטון שמעבר לכביש". צילומים: עדנה בר־רומי

הוא נולד בבית אלפא, גדל ברמת־יוחנן ועכשיו הוא מגיע לכוכבים: בסוף החורף התחברה קרן לייזר, מיליארד ק"מ אורכה, ששיגר אוריון, אל 15 קרניים נוספות שיצאו מתחנות־שיגור ברחבי העולם, ויצרה פסל חללי - 'סופר־קתדרלה', הנוסקת אל האינסוף ● אוריון, פסל־חלל ראשון, מקיים מגעים עם נאס"א

אריאלה רינגל־הופמן

ביום השנה השלישי למותה של רותי אשתו, שיגר עזרא אוריון קרן לייזר, מיליארד קילומטר גובהה, ללא גג, שנסקה לחלל במהירות האור. הוא קרא לזה פיסול בין־גלאקטי. ב־27.4 השנה, ביצע שיגור נוסף. ב־20.30 בדיוק, ממצפה הכוכבים שבבר־גיורא, יצאה קרן לייזר, שהתחברה לקרני לייזר נוספות, שיצאו מ־15 תחנות שיגור בחצי הכדור המערבי, ויצרה יחד איתן 'סופר־קתדרלה' הנוסקת אל האינסוף. השיגור נמשך 55 דקות ו־33 שניות בדיוק. עמדו שם כמה עשרות אנשים - אנשי אמנות, אנשי סוכנות החלל הישראלית, בני משפחה וידידים - ששמו עליהם מעילים, כי בירושלים ובסביבותיה קר תמיד. על מסך וידיאו גדול הוקרנה תמונת ה'סופר־קתדרלה', ורעש המאיץ, שרפק בפולסים קבועים, ליווה את הנואמים. וכל הדבר הזה היה מפליא מאוד, בחשיכה הכבדה, בקרן הנשלחת. בידיעה שממש ברגע זה, במצפי הכוכבים במצרים, ביוון, ברוסיה, בלטביה, בגרמניה, באוסטריה, בצרפת, בספרד ובצפון מזרח אמריקה, מישהו טורח ללחוץ על המתג. מופלא בתכלית הכל־כך מופשטת.

וזה מה שאוריון אמר שם, רגע לפני השיגור: "הפיסול, עד היום ולכל אורך ההיסטוריה שלו, הוא פיסול מקורקע. הגיעה שעתו לפרוץ מתוך שדה הכבידה של כדור הארץ, אל טווחי מערכת השמש ומעבר להם, אל הטווחים הבין־גלאקטיים. ברגעים אלה הולכת ונבנית במהירות האור, מחצי הכדור הצפוני, 'סר־קתדרלה', אשר בעוד כמה דקות תצא לדרכה בניצב למישור שביל־החלב. רוברט סמיתסון טבע את המושג 'פיסול ייחודי לאתר', והאתר של קתדרלה זו הוא שביל־החלב".

כ־17 שנים קודם לכן, כשיצק עזרא אוריון את המודלים הראשונים לשדה הפסלים שעל מישור הציון - שדה פסלים שמעולם לא התרומם - הדרכתי

בבית־ספר שדה־בוקר. עזרא היה המנהל. יום אחד הוא לקח שלט גדול, כתב עליו 'כאן יוקם שדה פסלים', ותקע אותו במישור. זה היה מישור לס צהוב, מהודק, מסומן בגלגלי המשאיות שעברו שם, ושוליו מכוסים אבני־צור כהות. לימים הפך השלט לנקודת־ציון בו. כשפעם הסתבכנו במישור, בליל ירח קיצי, הבנו שאנחנו נעים בסיבובים, כשחזרנו ופגשנו את השלט שוב ושוב.

באותם ימים ממש צמח הקשר בין עזרא אוריין ובין רותי שרמי. או חשבתי, ששדה־בוקר הוא המקום הכי יפה בעולם. וקודם שסיימתי את השירות הצבאי ועזבתי את המדרשה, כבר בכיתי מגעגועים. גרנו שם בשורת חדרים שקראו לה רווקייה. בימי שמש חודפיים היינו יושבות, רותי ואני, על החלון ומחסלות קופסאות של שוקולד למריחה. מעולם לפני כן, ואף פעם אחרי כן, לא נגעתי בשוקולד למריחה.

לרותי היה חוש־הומור מדהים, ויכולת מופלאה לאתר אבסורדים. היא היתה יפה ומוכשרת, ואת מידת הפתיחות הדרוך שנתגלו בעזרא, אחרי מותה, אפשר אולי לייחס לשנים שחיו ביחד.

רותי מתה בטביעה בבריכה של מדרשת שדה־בוקר. מותה היה אסון חייו. כשהובאה לקבורה, לפני שש שנים בדיוק, בסוף יוני 1986, בקיבוץ שבו נולדה וגדלה, בעמק־עזו, היה מסע הלוויה נורא, דווקא משום שמחת הפגישות שהיו בו. אנשים שלא ראו זה את זה הרבה שנים, נפגשו שם, מעל הקבר הטרי, תחת עצי האורן, כשאבא של רותי קרא קטע מ'הנסיך הקטן' ואמר דברים נפלאים לזכרה.

רותי השאירה אחריה שני ילדים. את עומר, שהיה אז בן שש, ואת מורן, שהיתה תינוקת, וכבר בפנים הקטנות ניכר הדמיון הכל־כך גדול לרותי.

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עזרא אוריון נולד בקיבוץ בית־אלפא של השומר הצעיר. הוא היה בן חמש וחצי בעת הפילוג הגדול במפא"י. אברהם הרצפלד בא אז לפסוק בעניין בית־אלפא ואמר, שאנשי השומר הצעיר צריכים לעזוב. אבל מאיר יערי אמר, שזה קיבוץ א' שלהם והם לא יזזים. וכך, המשפחה של עזרא אוריון ומשפחות אחרות אספו את עצמן והלכו לרמת־יוחנן.

לצבא התגייס באוגוסט 53'. חודשיים אחר־כך כבר נשלח המחזור שלו לקורס קציניים. גדליה גל, היום חבר הכנסת, היה מפקד מחלקה באותו מחזור. אלישע שלם, מי שהפך עם השנים לאגדה בצנחנים, עשה יחד איתו את הקורס – שמונה חודשים במחנה 80'.

של שתיקה. לאחר ניצחון – אמר דדו, כשהוא שוקל כל מלה – חייבים לטפל בחומרה בתופעות של התערערות המשמעת. הוא שחרר מיידית את האנשים משירות המילואים, וגם ביטל לסיירת סיור מתוכנן לסיני.

עם השנים אסף הסיפור גובה, נוספו גרסאות. הן התערבבו עם סיפור העלייה השנייה לחרמון בסתיו 73'. אוריון, או כבר מג"ד, עשה מסע חישול למפקדת הגדוד עד הפסגה, שהוחזקה בידי הצנחנים. שבועיים אחר־כך, בעיצומה של סופת שלגים, שידרו אותם צנחנים אותות־מצוקה. כוח חילוץ של סיירת מטכ"ל נשלח לסייע להם, הסתבך בדרך, אחר החזיילים קפא למוות.

ב־72' קיבל דרגת סא"ל ואת הפיקוד על גדוד חי"ר באותה חטיבה. מ־79' הדריך באימוני שלגים בחטיבת חרמון. ב־87' השתחרר. „נפרדתי", הוא אומר, „ללא כאב. מה שהבאתי משם זו היכולת לבחור יעד מתוך מורכבות, להינעל ולחתור אליו. את ההרצאה הראשונה בצבא שמעתי באוריטוריום של בה"ד 1. על הלוח היתה רשימה של עשרת עקרונות המלחמה. הראשון שבהם היה דבקות במטרה. וזה מה שנשאר לי".

■■■

משדה הפסלים המתוכנן של עזרא אוריון בשדה בוקר נשארו המודלים. נשאר קטלוג מתערוכת־יחיד שהוצגה ב־74' במוזיאון ישראל. זה היה צריך להיות שדה־פסלים ענק, המשתרע על עשרות רבעים שגובה פסליו עשרות מטרים. בזיכרון שלי רשומות גם התפעלות, גם בהלה מפני צמיחת המונומנט הבלתי אפשרי הזה בתוך הנוף.

קורם לכן, אחרי שסיים את בית־ספר בצלאל, עשה תערוכת־יחיד בעין־חרוד; תערוכת־יחיד במוזיאון חיפה לאומנות חדשה; השתתף, ב־65', בתערוכה קבוצתית 'אמנות ישראל', בארה"ב. למד בסנט־

'מצבו של האדם בהר־סדום'. איך מפיקים חיים מים־המוות

„המולדת שלי היא כדור הארץ, העם שלי הוא מין האדם. התרבות הזו, שמעלה וקוברת את המתים בפסגות על קצות שיאי המאמץ הסלעי, לעבר האינסוף, חדורה בתוך הפיסול שלי"

באפלולית קיר השק"ם של הבסיס – מבנה אבן גדול, שריד לתקופה הברית – ודיברו בקול נמוך. החיילים אמרו: 'הנה, הנה מאיר הר־ציון'.

אורין הלך לגולני. מאוחר יותר, בחורף 55', כשהוקמה סיירת גולני בפעם השנייה – הסיירת התפרקה אחרי שנתפסו ונחשפו אורי אילן וחבריו – מוגה לסגן המפקד. על משמר הכבוד, בהלוויה של אורי אילן, פיקד אורין.

הוא שירת בסיירת עד 56', עד השחרור. במבצע קדש כבר היה איש מילואים, שנבחר יחד עם 12 קצינים ומש"קים ליחידה סודית שהוקמה אז. הם היו אמורים לחדור לסוריה, דרך החרמון הדרומי, לרדת למחנה קַטַנַה, לחטוף קצין סורי בכיר ולהעבירו לפיקוד צפון. בפיקוד צפון חשבו להחזיק בו כבן־ערובה, אם תצטרף סוריה למלחמה. בסופו של דבר, כשנראה שסוריה אינה ממהרת להגיש סיוע למצרים, בוטל המבצע.

הקצין שארגן את הכוח, אברהם אורנן, הקים לימים את סיירת מטכ"ל.

באביב 57' קיבל אורין פיקוד על סיירת של חטיבת חי"ר מילואים צפונית. במלחמת ששת הימים הוביל את היחידה במסגרת ההבקעה לרמת־הגולן. האנדרטה שהקים כמה שנים אחר כך לזכר הנופלים, ממוקמת בעלייה לרמה מגשר בנות־יעקב, על כביש קוניטרה, מול קיבוץ גדות. גובהה 14 מטרים, בטון חשוף, בנויה על מוצב דר־פלוגתי סורי, משתלבת במערך תעלות הקשר שהזמן מחק אותן.

שבועיים אחרי הפסקת האש, בסוף יוני 67', הוביל עזרא אוריון כוח צבאי אל פסגת ג'בל א־שייח', פסגת החרמון, נקודת גובה 2814 מטר. ב־23.6 יצאו ממג'דל שמס, בצהריים. ב־24.6, בשעה 11.00, הגיעו לפסגה כ־50 חיילים, בדרך בין מג'דל שמס לפסגה, על קו הרכס. זו היתה הפעם הראשונה שכוח ישראלי טיפס לאותה פסגה, להוציא את גרעיני 'מחנות העולים' בשנות ה־30'. מלמעלה נפרש מרחב דמשק, הר הדרוזים, מחנות הצבא הסורי בקטנה. הם עשו צילום קבוצתי וירדו.

למטה חיכה להם קצין צעיר. אתם עצורים, הודיע להם, על־פי פקודה של אלוף הפיקוד, דוד אלעזר. הכוח הובל למשטרת ראש־פינה, שם התקיים בירור עם האלוף. השיחה נמשכה לא מעט. דוד אלעזר דיבר לאט. אוריון דיבר לאט. בין לבין עמדו רווחים גדולים

רותי אוריון. יכולת מופלאה לאתר אבסורדים

רותי מתה בטביעה בבריכה של מדרשת שדה־בוקר. מותה היה אסון חייו. כשהובאה לקבורה, לפני שש שנים בדיוק, בסוף יוני 1986, היה מסע הלוויה נורא, דווקא משום שמחת הפגישות שהיו בו

מרטין, בית־ספר לאמנות בלונדון; למד ברזיאל־קולג' לאמנות. עשה שם תערוכת־יחיד, השתתף בתערוכה קבוצתית.

בראשית שנות ה־80' החל לעבוד על מה שנקרא היום 'פסל והת לירוחם', ירוחם הוקמה בראשית שנות ה־50' – צריפים צהובים במרחב שומם, ותושביה היו אמורים לעבור בכניית אבן־חול במכתש הגדול. עליבות המקום נשמרה עד שנות ה־70', וגם המלחמה הקשה לשינוי תרמית בשנים האחרונות, לא מוחקת את עקבות המצוקה. הפסל של עזרא אוריון, בהגדרה שלו, לא עושה איזו לפולקלור של ירוחם באותן שנים. הוא מדבר – בירוחם עם אחוזי אבטלה גדולים פערים קשים בחינוך, דרך שני של מצוקה חומרית וסביבתית – על ה'הומו ארקטוס', האדם הזקוף. הביטוי הכי קיצוני של האנטי־בירוחם, אנטי־תזה למצב הסופני שלנו.

העמדת הפסל הושלמה באחרונה בסיוע האדריכל סעדיה מנדל, שהיה אדריכל היישוב, ואדריכל הנוף צבי רקל. קר־האופק, שנשקף מאותה גבעה שעליה הועמד הפסל, היה נקי ומעוגל. על גבול הארץ הנושבת והמדבר. בטון דרוך, רווי־פלדה. 20 מטר גובה. צבוע לבן. "התעקשתי על לובן חזק שקוף. הפסל הזה, שהוא על גבול היישוב וגם בלבו, הוא לא אנדרטה לנופלים, לא מקום שקט וקודר. מעין כך שיגור אנכי, שעם המדרגות העולות אליו והמגלשה היורדת בצדו השני, מיועד גם לילדי הפעוטון שמעבר לכביש הסמוך".

עזרא אוריון: "המולדת שלי היא כדור הארץ, העם שלי הוא מין האדם. על קווי הרקיע של הר־הנגב וצפון סיני, ערוכות מאות תלוליות קבורה עשויות גלי־אבן. בבי"ס שדה קראנו להם 'טומולי'. בהם קברו, כנראה, נוודים מגדלי צאן, את ראשי השבטים שלהם. שרשרות התלוליות האלה נמצאות על רכס חלוקים מול מדרשת שדה־בוקר, על הר חורשה שבהר הנגב הגבוה, ועל ג'בל עריף א־נאקה שבצפון סיני. התרבות הזו, שמעלה וקוברת את המתים בפסגות על קצות שיאי המאסף הסלעי, לעבר האינסוף, חדורה בתוך הפיסול שלי.

"צפון סיני היה בתוך מרחב ההדרכה שלנו בבי"ס שדה. עברנו בו לא מעט קבוצות מיטיבות לכת. עם שתיים מהן, ב־'81 וב־'82', הגענו לרגלי עריף א־נאקה, בצפון סיני, ובנינו לרגליו, מול הפסגה, גרם־מדרגות, שאוסף גובה לכיוון הפסגה, בנוי אבני גיר מקומיות. שוב, כך־שיגור מדברי, השולח את ההכרה האנושית על־פני השכבות המוזרקרות של ההר, אל הטווחים האסטרונומיים.

"כמה חודשים אחרי הביצוע באו אירועי ימית, והפרידה מצפון סיני. אין לי שום מידע על זה. אני מקווה, שאם ישתפרו היחסים עם המצרים, נוכל להיכנס דרך מסוף ניצנה ולשקם את הפסל".

באותו זמן, בסתיו '81', יצא עזרא אוריון עם משלחת להימאליה. גם שם, בגובה 4,100 מטר, בבקעה של רכס האנפורנה, אחר מרכסי הפסגות של האוורסט, הקים גרם־מדרגות. שנתיים אחר־כך חזר לאותו מקום, הפעם עם רותי, לעבודות תחזוקה ושיפוצים. בדרך חזרה סחב על הגב, שבוע והליכה עד

המשך בעמ' 56

מלחמת הכוכבים של עזרא אוריון

(המשך מעמ' 39)

למטה, אבן שהוצגה אחר־כך בתערוכה במוזיאון ישראל. 'פיסול בהימאליה' קראו לה.

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בשנים שבהן אוריון ניהל את בי"ס שרה בשדה בוקר, למדנו מושכל ראשון – שסיבּ הסלע עשוי ללמד על העבירות בשטח, ושטופוגרף רציני לא ישתמש במלה 'מול' כדי להגדיר נקודת־ציון. באותן שנתיים עשינו טיולי ירח להור־ההר, מקום קבורתו המיתולוגי של אהרן הכהן. נשאר־נו לישון בשטח בימים של מיפקדי יעלים, מיפקדי דורסים, מיפקדי טורפים. טיאטאנו את מדרונות המכתש הגדול כדי לגלות סימנים לשברים בני מיליוני שנים. סחבנו סלעים ענקיים מכוסים בחוזיות. רבצנו על הקרקע ועקבנו אחרי סחביות מדבריות ממרחק חמישה סנטימטר. בין לבין היו גם שיחות־נפש. ופעם אחת, בגיל 20, כשרותי ואני ביכינו את עלומינו החולפים, היא אמרה: בכל פעם כשתחשבי על הקונה תזכרי שזה קורה גם לי, יהיה בזה נחמה.

אלא שלה – זה כבר לעולם לא יקרה.

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ארבע עבודות פיסוליות עשה אוריון על השבר הסורי־אפריקני: ב־'80, בפרויקט תל־חי, הנחת סלע גיר ענק, 12 טון, בבסיס הסחיפה של גיא היורד מכפר־גלעדי. ב־'84 – עבודות במסגרת שלושה ימי מפגש אמנים על הר־סדום, קו אבן היורד אל הים ונבלע בתוכו. ב־'84 עבודה נוספת – במעלה נחל דרגות, חריץ אל קו המצוק, ובסוף '90, הפסל על מצבו של האדם בהר־סדום.

המכונית בדרך לשם מעלה אבק. קודם היה שם רק מצפור, עמדת תצפית על מפעלי ים־המלח, סיפור ההצלחה הגדול של המדינה המתחדשת. איך מפיקים חיים מים־המוות, וכמה יפה מאבקנו באיתני הטבע. היה שם שטח כבוש, מוקף מעקה צבוע שחור־צהוב, „צבעי שריון", אומר אוחיון. הפסל שהקים שם, הוא אומר, „הדבר הכי משמעותי שעשיתי על הקרום". 235 אדני רכבת, שהובאו מהתחנה הישנה בחיפה, ממוסמרים לסלע, כמו מטפסים אל אובליסק של 25 מטר פלדה, הנשענת על אלומה של קלונסאות יצוקים בעומק 10 מטרים. כשעזרא בא להעמיד את הפסל, בא איתו קבלן מדימונה עם שני מלחימים רוסים ובדואי אחר, שעברו בחום הכבד.

במקום הזה, בשנים שאינן שנות בצורת, יורדים כ־50 מ"מ מים. במשך השנים, הפסל שנראה מרחוק שחור ומקורס חום, נאפילו חום בהיר, ייללך ויקבל, כך אוריון צופה, את הגוון העמוק של החלודה. ומרחוק יישמע נהם מכונות המפעל, ייראה הכחול של בריכות הייבוש, וכתם כתום של העשן שעולה מהאורובות.

ואלס מריינריס – קניון צחיח, מעין הגרנד־קניון שעל המאדים. בקר־המשווה של הכוכב הזה מגיעה טמפרטורות אמצע היום לאפס מעלות, והיא יורדת למינוס מאה מעלות באמצע הלילה. במיליארדי השנים האחרונות, מעריכים, לא היו שם מים וורמים, רק זיכרונות סוריאליסטיים של שיטפונות. אין אורוזיה. רק קצת גלישות.

היו צריכים לעבור שש שנים, ומותה של רותי, מיום שעלה הרעיון לפיסול על הכוכב, עד שמימושו נראה היה קרוב. וזה מה שהגה עזרא אוריון: רכב־החלל של נאס"א, שנמצא על המאדים ולוקח דגימות, ינוח לרגע ממשימותיו, ולשנייה אחת קצרה יתפנה להרים את אחת מזרועות המתכת שלו, כדי להניח אבן על אבן. תשובת האדם לאנטרופיה, למאמץ החומר להתפרק ליסודותיו. אחר־כך, כשכבר רובר ברכבי־חלל משוכללים יותר, ריבר אוריון על סימון קו אבנים, שיירד אל אותו מצוק של הואלס מריינריס.

באוגוסט '82 התקיימו שתי השיחות הראשונות במעבדות להנעה סילונית בפסדינה, קליפורניה. הרעיון להציב קו אבנים אל שפת המצוק על־ידי רכב המאדים 'מרס־רובר' נדון במפקרת נאס"א בוושינגטון עם ד"ר ג'פרי בריגס, רכז מחקרי השמש של נאס"א, ב־19.1.88 וב־6.6.90. „בתום השיחה השנייה שאלתי את ג'פרי בריגס, אם זו הפעם הראשונה שרעיון של פיסול במערכת השמש מוצע לכם על־יד פסל כלשהו. כן, הוא אמר, למיטב ידיעתי". בכל מקרה, הוברר, כי התכנית ריאלית, אם בכלל, רק בסוף העשור.

בתקופת ההמתנה לרכב־החלל, שיבצע את הפיסול המדברי על המאדים, נולד הפרויקט של הפיסול הבין־גלאקטי, הפיסול במערכת השמש. ה'סופר־קתדרלה' שיצאה לדרך.

במאי השנה הוציא אוריון מכתב לפרופסור עקיבא בר־נתן, רכז סוכנות החלל הישראלית. הנדון: שיתוף הפעולה עם נאס"א. אוריון מדבר על שיגור 'סופר־קתדרלה' 3 ו־4; על פיסול רובוטי על המאדים; על פיסול רובוטי על הירח; מוצע לבחון אפשרות, הוא כותב בסוף, של מיסוד הקשר ביני וביניכם כ'פסל חלל' ללא שכר, כיוצע לפיסול חלל.

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בכניסה למוזיאון לפיסול מדברי של עזרא אוריון במדרשת שדה־בוקר, על השולחן מימין, מונחת ערמה של דפי הדרכה צהובים למבקר. שטח המוזיאון 80 מטרים מרובעים. תיעוד של 20 שנה. בהיכנסך, כתוב שם, פנה שמאלה. עבודות ברזל מולחם. 150 מטר שרשראות עוגנים מוצבים בכניסה לבסיס חיל־האוויר בתל־נוף. אחר־כך מודל שדה הפסלים הענק, שאמור היה להיות מוקם על שפת מצוק שדה־צין: עבודות משנות הלימודים בלונדון, צילום מכתב של הנרי מור, פסל המעלות, צילום גרם־המדרגות שנמצא בקרית־יובל, ירושלים; צילומי עבודות בשדה הפסלים במצפה־רמון, במוזיאון ירושלים. נוע ימינה, כתוב שם, ואחר־כך נוע שמאלה. ושוב נוע ימינה. ואי־אפשר לטעות בסגנון.

בחוץ, צמוד לקיר הדרום מזרחי של המוזיאון מוצב דגם בקנה־מידה של 1:10 של 'קתדרלת שדה הפסלים'. הדגם המוקטן דיו לגובה אדם. אפשר לדרוך אליו, לדחוף את הראש לתוך פיר מוארך שמולך כלפי מעלה, ושהרוח העוברת בו משמיעה קול עמום, רחוק. ■

'פסל זהות לירוחם'. אנטי־תזה למצב הסופני שלנו

STEVE NORTHUP—BLACK STAR

rays. A popular theory held that the Great Annihilator was actually a gigantic black hole, a million stars collapsed into a single object so dense that its gravity wouldn't let even light escape. New information gathered by the Very Large Array radio telescope in New Mexico and published in *Nature* has found that this theory was slightly off the mark. The Great Annihilator does indeed seem to be a black hole, but it's only as massive as a single star, and it's merely close to, not right at, the center of the Milky Way.

An important part of the theory, however, still seems valid. It holds that as additional gas falls into the black hole, it is compressed and heated. This process creates positrons, one form of the strange stuff known as antimatter; as the positrons are flung out into space, they eventually collide with interstellar clouds. Result: enormous explosions.

Every subatomic particle has a corresponding antiparticle, identical in mass but differing in one crucial characteristic, like electric charge. Matter and antimatter destroy each other whenever they meet, and because interstellar clouds are full of electrons, these particular collisions have been fingered as the power behind the Great Annihilator.

Black holes are thought to be rather common in the galaxy, so why has only one Great Annihilator been found? The answer may be that the galactic core is unusually full of gas clouds; these provide lots of matter for the antimatter to run into. Other parts of the galaxy are just too empty for black holes to create much of a bang. ■

EYES ON THE SKIES: The Great Annihilator's telltale emissions were detected by scientists using the Very Large Array radio telescope in New Mexico

ET CETERA

RISK-FREE OYSTERS? Raw oysters often carry the hepatitis A virus, which causes a truly unpleasant (though not necessarily fatal) liver disease. Now comes a vaccination of sorts, and one that many people will find easier to swallow than the oysters. According to a report in the journal *Epidemiology*, chasing oysters with a glass of wine or a cocktail can reduce the risk a whopping 90%, no matter how many oysters are downed. It's the first time anyone has shown alcohol can prevent viral illness.

ROUSING NEWS An answer to impotence? Writing in *Science*, Johns Hopkins researchers say they have found what may be the essential signal that triggers erection: a tiny secretion of nitric oxide by penile nerves. An ointment that promotes the production of nitric oxide might alleviate impotence; one that inhibits production could relieve priapism, prolonged erections unrelated to desire. Also, if nitric oxide turns out to rouse the clitoris, medicated cream could help women reach orgasm.

MILESTONES

AILING. Olivia Newton-John, 43, pert Australian pop singer whose hits include *Have You Never Been Mellow* and *Physical;* with breast cancer; in Malibu, California.

RECOVERING. Pope John Paul II, 72, after a four-hour operation to remove his gallbladder and a benign tumor the size of an orange from his colon; in Rome. Biopsies taken before and during surgery showed the growth was not malignant. Doctors said the Pope's current distress had no connection to injuries he sustained in 1981 when Mehmet Ali Agca shot him in the abdomen during an assassination attempt.

DIED. Hamid Reza Pahlavi, fiftyish, half-brother of the late Shah of Iran and reportedly the last imperial-family member in Iran; of a heart attack; in Tehran. Pahlavi had served 13 years of a life sentence on drug charges in Tehran.

DIED. Albert Pierrepoint, 87, Britain's best-known hangman, who dispatched 433 men and 17 women in a 25-year career; in Southport, England. Pierrepoint, whose father and uncle were executioners, hanged World War II traitor William Joyce and Ruth Ellis, the last woman executed in Britain. He defended the noose as humane and quick (11 sec. when done properly). But after retiring in 1956, he became a vigorous opponent of capital punishment: "The death penalty never once acted as a deterrent."

DIED. Deng Yingchao, 88, widow of Chinese Premier Zhou Enlai, adoptive mother of present Premier Li Peng and one of the country's most prominent women; in Beijing. A Long March veteran known for her support of women's liberation, Deng was a member of the Politburo and chairwoman of the Chinese People's Political Consultative Conference.

TEL AVIV UNIVERSITY אוניברסיטת תל-אביב

תאריך: 15.9.92

אל: עזרא אורין

מאת: פרופ' דוד אביר

שלום רב!

ISY News, ובזרף הנה גליון של
המכיל את הכתבה על הסיבוב-בלייתר שלקח
(בעמ' 5). הראיון התקיים בין כל באי
הכינוס International Space Congress,
שנערך בוואשינגטון האוניברסיטה (ושתתפו
בו כ-5000 איש). התאכזבתי את העורך הגבוה
מאוד.

אני תיכף עורכים גיליון - תכבל
לכתבה ושירות למו"ל.

בברכה,

דוד

22/9

הטאטע פתח תקוה

FAX: 972-3-6429540
קרית האוניברסיטה, רמת אביב, ת.ד. 39040, תל-אביב 69 978, טל. ~~420111~~ 03-6408173

ISY NEWS

July-August 1992

INTERNATIONAL SPACE YEAR 1992

D.C. STUDENTS HOST NASA ADMINISTRATOR ON "ISY DAY"

Washington, D.C. — Rockets soared, robots clanked, and astronauts mingled with schoolchildren when Dunbar High School celebrated its own International Space Year Day on June 3.

NASA Administrator Daniel S. Goldin and six astronauts were among those on hand to commemorate ISY and help dedicate the school's Enterprise Mission — an ongoing program designed to help students improve math, science, and technology skills by applying them to space-oriented problem-solving situations.

"ISY Day" began with the launching of student-built model rockets, to the delight of elementary schoolers and community leaders on hand to watch the festivities. Welcoming the audience to the launch were NASA astronauts recently returned from the ATLAS-1 shuttle flight, which was dedicated to ISY's Mission to

ISY DEFORESTATION CONFERENCE STUDIES GLOBAL SYSTEM

São José dos Campos, Brazil — Nearly 200 leading scientists and government officials discussed for the first time ways to launch a permanent satellite monitoring system for the Earth's endangered forests at an ISY conference here May 27–29.

The ISY World Forest Watch Conference on Global Forest Monitoring culminated a three-year model international research effort initiated by the Space Agency Forum on ISY (SAFISY). With 29 space agency members and 10 international affiliates, SAFISY is coordinating global research activities for ISY 1992.

The Brazil conference reviewed the results of ISY deforestation research projects, and it also examined ways to maximize efficiency and improve scientific return through greater coordination of independent national spacecraft and the data they generate.

"For our goal of a global forest monitoring program, this conference was indeed unique," said Jean-Paul Malingreau of the Joint Research Centre (JRC) in Ispra, Italy, operated by the 12-nation European Community. JRC was a co-organizer of the conference along with the host Brazilian National Space Research Institute (INPE), under SAFISY's auspices.

Malingreau said that preliminary recommendations of the meeting will be presented at the International Society of Photogrammetry and Remote Sensing conference and the World Space Congress, both being held in Washington, D.C., in August and early September.

Subsequently, said Malingreau, the recommendations will be refined at the Asia–Pacific ISY Conference in Tokyo in November, with a view toward developing a global forest surveying system using satellites.

Among the countries represented at the Brazilian conference were Argentina, Austria, Bolivia, Brazil, Cameroon, Canada, Chile, China, Colombia, Cuba, Ecuador, France, French

Planet Earth. Crew members presented the school with a commemorative plaque and conducted question-and-answer sessions with students.

Demonstrations, exhibits, and tours of Enterprise Mission facilities continued throughout the day. There were physics experiments, computer activities, videos, a student-built planetary rover, and an "Earth as Art" display. A luncheon provided the opportunity for high school students to talk with visiting aerospace professionals.

ISY Day culminated a year-long Enterprise Mission program that has become a model of its kind. NASA, the National Association of Partners in Education (NAPE), and Science Applications International Corporation serve as its primary sponsors. Additional organizations and volunteers contribute everything from cash to computer equipment, internships, and professional services.

"The Enterprise Mission represents a collab-

(continued on page two)

Marcio Barbosa, head of INPE (with mustache), addresses World Forest Watch opening session.

NEW MARS ERA OPENS

Washington, D.C. — A series of planning meetings initiated by NASA and the European Space Agency (ESA) during ISY 1992 heralds a "Second Era of Mars Exploration" highlighted by international cooperation, according to the Director of NASA's Solar System Exploration Division.

The first era reflected the bipolar competition of the Cold War. It consisted mainly of U.S. and U.S.S.R. missions, notably NASA's Mariner and Viking series of the 1960's and 1970's.

"This time, many more nations are involved, and we'll all be working together," said Division Director Wes Huntress.

The promising new cooperative era is unfolding along near- and medium-term planning tracks, Dr. Huntress noted.

The near term includes the launch in September of NASA's Mars Observer, followed by Russian missions in 1994 and 1996, a '96 mission by Japan, and a NASA '96 mission if funds are approved — all with international consultation and varying degrees of international participation.

The subsequent medium-term goal, developed during a series of meetings in Europe and the U.S. this year, is "an international network" of robotic stations on the Martian surface, Dr. Huntress said — as recommended last October at the 2nd Pacific ISY Conference, where Huntress co-chaired a Solar System Exploration working group with senior space officials from Europe, Japan, and Russia. (See *ISY News*, January '92.)

The core of the medium-term planning effort is NASA's Mars Environmental Survey (MESUR) program for 16 robotic landers and ESA's Mars Network (MARSNET) program of three landers, both for the period from 1999 through 2006.

Russia and Japan have also participated in ESA/NASA meetings on turn-of-the-century Mars projects, said Dr. Carl Pilcher, head of the Solar System Exploration Division's Advanced Studies Branch.

"The program is being designed so that we

(continued on page six)

ISY astronauts land on Mars. For additional details, see page seven. (photo by Glen Martin / Denver Post)

Guiana, Germany, Indonesia, Italy, Jamaica, Japan, Kenya, Mexico, Panama, Peru, Surinam, Sweden, Switzerland, the United Kingdom, the United States, Venezuela, and Zaire.

Representatives of these nations sketched various approaches to satellite surveying of the world's assets of tropical and temperate forest.

A primary focus of the conference was the continual deforestation of tropical rain forests, home for a rich diversity of animal and plant species and a vital resource that helps determine the world's climate.

Scientists at the meeting agreed that by implementing a global, systematic application of spaceborne sensors and methodologies, a more accurate assessment of deforestation is attainable.

To assist their deliberations, conferees heard reports on forest-monitoring capabilities of a panoply of Earth observation satellites, ranging from longstanding facilities such as the high-resolution U.S. Landsat and French SPOT to the European Space Agency's new ERS-1 and Japan's JERS-1, which are delivering cloud-piercing radar imagery.

(continued on page ten)

INSIDE

17/1/93

Italian Museum-to-Be (Maybe)

By Ken Shulman

FLORENCE — After seven extremely successful years as founding director of the Pecci Museum of Contemporary Art in nearby Prato, the Israeli critic and curator Amnon Barzel left Prato this past September to devote his energies to the yet-to-be-built Florence Museum of Contemporary Art, of which he had been named director. At the time, everything looked rosy: three of Florence's leading architects had completed plans for the center; a site — the abandoned 12,000-square-meter (130,000-square-foot) Officine Galileo factory in the city's Rifredi zone — had been found; and nearly half of the estimated $42 million needed to construct the center had been raised.

It seemed — and was — too good to be true, especially in a city that has made a tradition of resisting "contemporary" art since the 18th century.

"It's a mountain of obstacles," says the 56-year-old Barzel, doing his best not to be bitter. "You can't believe how many commissions and committees and superintendencies have to agree on this proposal before the museum moves forward. This seems to be the destiny of any public project in Italy."

Director in waiting Barzel.

Although Barzel's nomination stems back to the fall of 1991 — a nomination that was approved by all the city's committees, overseers, and political parties from the Christian Democrats to the Communists — he still has not received a contract. Nor has he been paid for the work he has done in Florence since last January.

"Last fall, one of the regional committees raised the issue as to why a museum that did not yet exist needed a director," Barzel explains. "They didn't understand that a museum director must work for at least three years before the museum opens, raising funds, making plans for exhibits and, most of all, collaborating on a daily basis with the architects."

Barzel's contract is not the only stalled chapter in the drawn-out saga of the Florence Contemporary Museum. A few months after construction began last May, work was halted when the Florence Superintendency of Architecture and Monuments learned of architect Marco Mattei's plan to demolish two of the factory's original walls.

Built in 1856, the Officine Galileo was one of the first factories constructed during the Italian industrial revolution. As an historical building, it is protected by the superintendency. The work stoppage dragged on through the fall, providing fodder for more committee meetings and motions. The museum's contractors also augmented their estimates.

Work resumed in November, but with only a token labor force, and only after the Italian Fund for Investment and Employment threatened to withdraw the $18 million it had allotted for the project in 1990. Based on what city officials have told Barzel, work should resume soon. And Barzel would like to believe them.

This is not the first difficult situation Barzel has confronted since coming to Italy in the 1980s. The realization of a museum of contemporary art in Prato appeared equally improbable when he accepted the challenge in 1985. While similar, the two situations have one major distinction, and a distinction that may in the end make the difference for Florence, and for Barzel: the Prato museum was financed by a private foundation; the Florence project is public.

"It is always dangerous to rely exclusively on public funding in Italy," Barzel says. "The political situation is just too unstable. And too complicated."

A deceptively energetic man beneath a carefully cultivated facade of distracted sloth, Barzel does not regret having left a secure position in Prato for the uncertainties of Florence. But he is not waiting at home while the myriad of committees and commissions debates whether to agree to agree. Last month, Barzel traveled to Turku, Finland's former capital, where he plans to realize a park of 30 sculptures under the auspices of Unesco for 1994. He is also in contact with a foundation in Istanbul for the realization of a museum of contemporary art in an abandoned fez factory on that city's Golden Horn.

"When I arrived in Prato," he recalls, both fondly and with regret, "all there was was an empty field. Not even an architect's model. But the museum was created. We must do the impossible in life. And I am doing it. If this city wants a museum, then I will make it. But I am not waiting around."

Ken Shulman is an American writer based in Italy.

At the I

International Herald Tribune

PARIS — For two more weeks, "Byzance," one of the season's most surprising shows for the novelty of much of its art, is on at the Louvre. Even to scholars, many of the 400 sculptures, paintings and objects associated with Byzantium will be known only through reproductions in art books.

Drawn from French public collections, many are preserved in out-of-the-way provincial museums and church treasuries. Few people could boast of having seen the beautiful 11th-century ivory cut

SOUREN MELIKIAN

out from a plaque, "Saint John the Baptist," belonging to the Musée des Beaux Arts at Lons-le-Saunier or the outstanding Syrian interpretation of an Iranian textile lent by the Musée Bosquet at Meaux.

Even the works from Paris institutions include many that are rarely seen. Some are tucked away in little-known museums, such as the Cabinet des Médailles at the Bibliothèque Nationale. Others, such as manuscripts and textiles, are shrouded in obscurity for protection.

No wonder that the exhibition gives the visitor the impression of entering a continent of unknown cultures, the more so as the concept of "Byzantine art" is in urgent need of being redefined. Too many utterly different arts — from Christianized Greece, from Italy, from the Semitic Middle East and, most absurdly still, from Armenia and Georgia — are amalgamated under that all-purpose banner. Considerable uncertainty surrounds the actual geographical origin of many items and their dating, with endless arguments going on among scholars.

Most ironically, the hesitation extends to the art attributed to the capital of Byzantine Greece itself, Constantinople, now the Turkish city of Istanbul. This is even true of early sculpture, at the beginning of the show.

מה אפשר לעשות

מדריך העיר / 28.1-22.1 • אסתר זנדברג

לא כדאי להיות אישה. שלושים כפול ארבע

בובון קישוט

היו ממש נפגעים, מזימתו של הגאון, בעזרתם ה־ אדיבה של בתו אנני ונכדו צ'רלס באבלס, צלחה להפליא. בעיתוי מקרי לחלוטין זוקרן כאן החל מהשבוע סרטו המדובר של ריצ'רד אטנבורו ("גנדי") העוסק בקורות חייו של צ'פלין. רוברט דאוני ג'וניור, שלבוש רוב הזמן (כשהוא לא במיטה עם איזו קטינה) במדי הנווד, קיבל את התפקיד הראשי. ג'רלדין צ'פלין, גם היא בתו, משחקת בתפקיד אמו. אנתוני הופקינס, הוא ולא אחר, עושה את תפקיד הביוגרף, והמפקח מורס, השחקן ג'ון תאו, מופיע כאמרגן שנתן לצ'פלין את ההזדמנות הראשונה. צילם הצלם של ברגמן, סוון ניקוויסט.

כתב עת

אנחנו פלנקטון אנושי

"אלפיים" — כתב עת רב תחומי. עורך: אהוביה סלבן. ניליון 6

בקרה פתחתי בעמוד 112: "היקומיות היא בְּכוּת אקראית. אנחנו שושלת מוטציות בכאוטיות הזאת – עגה אנושית נידחת שלה. אנחנו פלנקטון אנושי־בראה־שואל מדע

קרי, פתיחת משכנה החדש במרכז גבעתיים בקשת הבאה, והיות שהיא תיאלץ למלא ערב ערב, אולם של 1,500 מקומות בבשר ודם, היה רצוי אולי שהיא תכין לעצמה עתודות אוזניים מתאי־מות. במפגש הנוכחי ישתתפו המנצח אשר פיש, הבמאי דייויד אולדן (שביים גם את האופרות הנ"ל) והתפאורן רוני תורן. הזמרים הסופיים בתפקידים הראשיים ירגימו מבחר אריות ודו־אטים. ינחה חיים קינן, ויהיה זמן לשאלות. המפגשים הבאים יתקיימו ב־20.3, לקראת "פולי־פוניה", וב־15.5, לקראת "הספר מסביליה".

תערוכה

כור מחצבתה

יחיאל שמי — "ספתח". גלריה גורדון. פתיחה: רביעי 27.1, 19:30. כניסה חופשית

מדי פעם מגיחה גלריה גורדון מערבות המכי־רות הפומביות שלה ושבה לייעודה המקורי: הצגת תערוכות אמנות לשמן. הפעם היא חוזרת לא רק לייעודה המקורי, אלא ממש לכור מחצבתה משברה הימים (יחיאל שמי, למי שזוכר

גרמניה, לאקטואלי יותר, אם כי, למעשה, לעולם יהיה לבעיה הזאת מימד אקטואלי. אין צורך להו־סיף כי הבעיה גם תמשיך ותפרנס תחומי יצירה והגות שונים, לטוב ולרע, עוד זמן רב. הסרט מפגיש אמנים ישראלים וגרמנים המדברים על האמנות ועל חיי היומיום, על העבר ועל ההווה. הדיאלוגים והראיונות מתרחשים על רקע קול־אי־ם ויזואליים ומוזיקליים. הסרט מתפתח על רקע עבודה משותפת בין אלרואי לבין הכור־יאוגרפית הגרמנייה סוזנה לינקה, שהופיעה בארץ בפסטיבל ישראל האחרון. אלרואי (31) ביימה והפיקה את "מפגש" בגרמניה ובצרפת. היא עסקה במחול מודרני ובצילום, ולמדה קול־נוע בבית צבי.

קישוט ופדרו. איור של דורה

בעד: "ירח סר" בנת. קחו עשרה קישלובסקים. תנו אחד פולנסקי, גם לא בשיאו.

צ'פלין. דאוני

כאוס, מהי ישות, מה זה להיות". השורות לקוחות מתוך הרשימה "פיסול קיומי" של הפסל עזרא אוריון. יש בגיליון גם מכתב נרגש של עמוס עוז לחוקר הספרות מרדכי שלו ("מרדכי יקר וקשה") בעניין אלתרמן, ומאמר שובה באניגמטיותו של הפילוסוף הפולני לֶשֶׁק קולאקובסקי, בשם "אגדת הקיסר קֶנְדִי", בין השאר. עלו והצליחו.

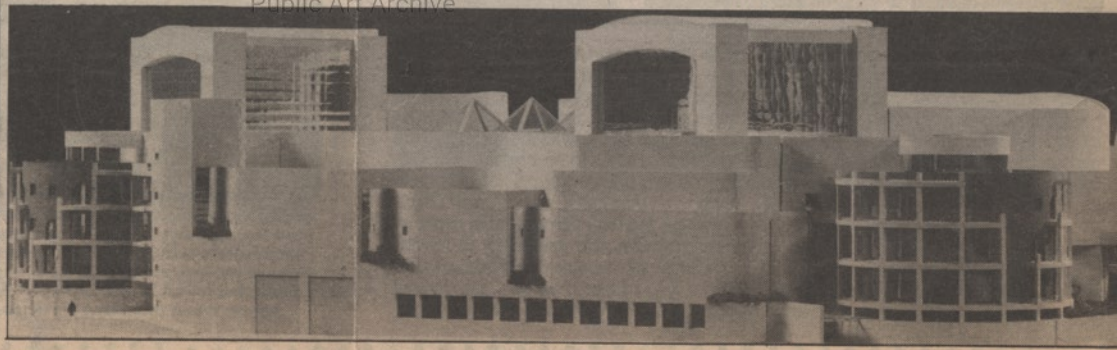
מפגש

אוזניים לכותל

"לקראת בכורה", לקראת האופרה "לה בוהם". נגה. שבת 23.1, 11:00. 15 שקל

אין צדק בעולם. דווקא למפגש מהסוג הזה, שאמור להכין קהל עם רצון טוב אך ללא ידע מוקדם לפגישה עם מוזיקה שלא בדיוק מושמעת ברשת ג', מגיעים רק המשוכנעים מראש. כלומר, קהל מנויי האופרה. כך לפחות היה בשני האירועים הקודמים שהפגישו קהל כזה עם יוצרי ומבצעי "אידומנאו", "קוולריה רוסטיקנה" ו"פליאצ'י". היות שהאופרה הישראלית החדשה עומדת כעת בפתחו של עידן חדש,

מקום ל־3000 אוזניים. דגם של בית האופרה במרכז גולדה



נגד: הפשיזם של מרי ז'ו לפונטיין בהלנה רובינשטיין. הניתוקים ב"קיטש וטוות" של פרידלנדר.

ישראלי

תמשיך ותפרנס

"מפגש". סינמטק, ש"ש 22.1, 14.30, ר"ש 27.1, 21:30

סרטה הקצר (43 דקות) של נטע אלרואי צולם בתחילת '92, לפני תאריכים הגזעניים האחרונים בגרמניה. אירועים אלה הפכו את נושא הסרט, הבעיה הישראלית־ שני, 25.1־23.1.

זאת ועוד:

הרצאה — פרופסור דוד הראל: "מי אמר שהמתמטיקה יבשה ולא מרתקת". בית ראובן. שני 25.1, 20:00. 18 שקל

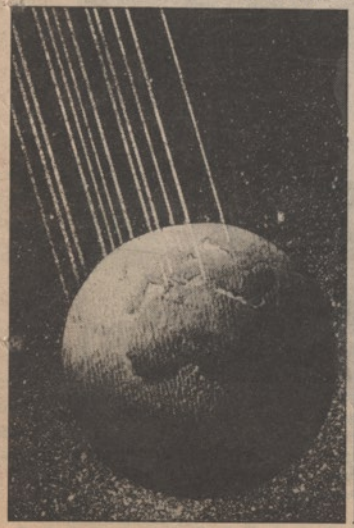
אף אחד לא אמר שהמתמטיקה יבשה ולא מרתקת. להפך. זה אנחנו, שקיבלנו שש בבגרות שלוש יחידות, היבשים והלא מרתקים. חבל שלא מרשים לנו להיכנס להרצאה בחינם, תמורת הדגמות.

הכוס הביולאומי הרביעי לאיחוד אזוטרי. סלון אוויה. 27.1־30.1

קבוצת MPH למען השלום, ההרמוניה והחיים היצירתיים מתכנסת בארץ מאז 1970. נושא הכנס הנוכחי הוא יישום אנרגיות, וידברו בו, בין השאר (באנגלית, עם תרגום סימולטני), על "בניית ירושלים הפלנטרית החדשה" ועל "השיר־ עוף האומניומן בשבע אנרגיות". מעניין אם הקרבה של מקום הכנס לשדה התעופה היא מק־ רית או לא.

הזדמנות אחרונה (כמי שעדיין לא השתכנע שלא כראי להיות אשה, אבל אם כבר, אז לפחות להיות סינקינאית): הסרט הישראלי "שלושים כפול ארבע" בסינמטק. הקרנות אחרונות: שבת־

רב תחומי. אלפיים



16-2-93 הארץ

תמונות קפואות מחיי האבולוציה

האם "איגלו" טבעי ענק שנוצר על פניו של טיטן, ירחו של שבתאי, מאפשר תהליכים כימיים הדומים לאלה שהובילו להתפתחות החיים על הארץ

ייתכן שבטיטן, ירחו הגדול של שבתאי, מתרחשים צעדים ראשונים של אבולוציה כימית הדומה לזו שהתקיימה בעברו הקרום של כדור הארץ והרבה לפני שהחיים התפתחות החיים על פניו. את האפשרות הזאת מציע ריד תומפסון, מאוניברסיטת קורנל, בניו־יורק, ארה"ב. טיטן עשוי ברובו קרח מים, אבל מחקרים שונים (שחלקם בוצעו על ידי חוקרים ישראלים) הראו בעבר, כי בנוסף למים הקפואים, מצויים בו גם חלק מהחומרים האורגניים ששימשו אבני בניין להתפתחות החיים על פניו של כדור הארץ.

פרופ' עקיבא ברנון מאוניברסיטת תל־אביב, המכהן כמנהל סוכנות החלל הישראלית (סל"ת), מצא שמלבד מים קפואים (המרוכזים על פני שטחו של הירח הגדול) וגזי חנקן ומתן הפזורים באטמוספירה שלו, מצויים בטיטן גם אתן ופרופן (שהם פחמימנים רוויים הדומים לגז המשמש להבערת אש בתנורי ביישול וחימום). חומרים אורגניים אלה הופכים בחלקם (בסיוע קרינת השמש) לאתילן ולאצטילן. החוקרים העריכו, שהאתן והפרופן שוקעים ומצטברים על פני הקרקע באוקיינוסים, בעוד שהאצטילן והאתילן יוצרים באטמוספירה שרשרות של פולימרים, המרכיבים "תרסיסים" דביקים, קרח המים, שכאמור מהווה את עיקר המאסה של טיטן, מצוי, לפי הערכה זו, על היבשה. תמונת מצב זו, המתארת גבולות תפוצה ברורים ומוגדרים של חומרים שונים, אינה מאפשרת התערבבות של חומרים אורגניים עם מים נוזליים. מכאן התפתחה ההערכה הרווחת, שלפיה אין אפשרות שעל טיטן מתרחשים תהליכים של אבולוציה כימית, העשויה ברבות הימים להוביל לאבולוציה ביולוגית (בדומה לתהליכים שהתרחשו באוקיינוסים של המים הנוזליים על פניו של כדור הארץ הקדום).

אבל עכשיו מציע ריד תומפסון תיאוריה, שלפיה

טיטן. אבולוציה רטובה מתחת לקרח

מאדים. אבולוציה מאובנת מתחת לחול

בהרבה מפרק הזמן הדרוש להפקת "תוצאות" של ממש. בכדור הארץ הקדום, לדוגמה, נדרשו ליצירת החיים הראשונים חצי מיליארד שנים של אבולוציה כימית.

על אף זאת, אם יוכח שתהליכים כאלה אכן התחילו על פניו של טיטן, אפשר יהיה ללמוד מהם רבות על התהליכים שהובילו ליצירת החיים בכדור הארץ. במובן מסוים, אפשר יהיה לראות את טיטן כבבואתו של כדור הארץ הבראשיתי. מעין תמונה קפואה מהעבר הרחוק.

בשנת 1997 מתכננות סוכנויות החלל של ארה"ב ואירופה לשגר במשותף חללית מחקר לא מאוישת לעבר כוכב הלכת שבתאי וירחיו. החללית, שתיקרא "קאסיני", תחוג במשך שנים אחדות סביב כוכב הלכת ותחקור גם את ירחיו. בהמשך, תשגר "קאסיני" גשושית מחקר עצמאית שתחדור לאטמוספירה של טיטן ותחקור אותה. הגשושית, שתיקרא "הויגנס", תאט את ירידתה באטמוספירת טיטן באמצעות מצנח. היא תכיל מצלמות ומכשירי מדידה שונים, שלתכננם שותף פרופ' ברנון.

אטמוספירת טיטן צפופה פי 1.5 מאטמוספירת הארץ, ולפי מחקרים אחדים, נראה שיורדים בה ללא הרף "גשמים" של מתן, אתן ופרופן. הטיפות, שגודלן מוערך כשווה לגודלם של אגוזים, נופלות באטמוספירה בקצב אטי יחסית של כקילומטר אחד בשעה (להשוואה: טיפות גשם־מים נופלות באטמוספירת הארץ במהירות של קילומטר בדקה). פרופ' ברנון אומר, שטיפות המתן שיפגעו ב"הויגנס" יתנדפו, אך טיפות הפולימרים של האתילן והאצטילן, היוצרות מעין תרסיסים דביקים, עלולות להיצמד למכשירי המדידה והתצפית של "הויגנס" ולחסום את "שדה ראייתם". עכשיו מנסים החוקרים למצוא פתרון לבעיה זו.

תמונה מאובנת נוספת של האבולוציה, אפשר אולי למצוא בכוכב הלכת מאדים. כך סבורים דייוויד דה־מארה ממרכז המחקר איימס של סוכנות החלל האמריקאית, נאס"א, ומרטין וולטר מאוניברסיטת מקווייר שבסידני, אוסטרליה. הם אומרים שאין להוציא מכלל אפשרות שבעבר הגיעה האבן לוציה במאדים עד לשלב של מיקרו־אורגניזמים חד תאיים, שהתפתחו בבריכות מים שנוצרו על ידי מעיינות חמים שנבעו בכוכב הלכת.

ולטר ודה־מארה מתבססים על תצפיות שהתבצעו בכדור הארץ ושלפיהן, מאגרי המינרלים הסמוכים לגיזרים ולמעיינות חמים מכילים כמויות גדולות למדי של אורגניזמים חד תאיים מאובנים. ריכוזים אלה נוצרים כאשר המים החמים, שבהם מתפתחים ומתרבים המיקרו־אורגניזמים, זורמים ומתרחקים ממקום הנביעה ותוך כדי כך

מולקולה בראשיתית

התפיסה המקובלת על רבים בעניין היווצרות החיים, מבוססת על הקביעה שרי טים בעולם הדומם, כדי להסביר את תופעת החיים. לפי הגדרות מקובלות, מערכת נחשבת כחומרים שונים. אבולוציה כימית מתרחשת כתוצאה מת־ גוברת כימיות ומשנויים מתמידים בסביבה. בכדור הארץ הקדום השתתפו ב"מש ומתן" המרתוני הזה גזים, כמו אמוניאק, מתן ופחמן דו־חמצני. חמצן חופשי (שהוא המפרק הכימי העיקרי בטבע) כמעט שלא היה באטמוספירה.

מולקולה בראשית

התפיסה המקובלת על רבים בעניין היווצרות החיים, מבוססת על הקביעה שרי בחוקים הבסיסיים של הפיסיקה הכימיה השולטים בעולם הדומם, כדי להסביר את תופעת החיים. לפי הגדרות מקובלות, מערכת נחשבת חיה אם היא מסוגלת לשכפל את עצמה.

לפי התפיסה הזאת, לאבולוציה הביולוגית קדמה אבולוציה כימית, שבה פעלו מערכות דוממות (שלא היו מסוגלות לשכפל את עצמן), בשרשרת התהליכים הזאת, נוצרו בשלב מסוים – באופן ספונטני – מולקולות שהיו מסוגלות לשכפל את עצמן ולארגן את סביבתן מחדש. אלה המולקולות הראשונות שחצו את הקווים שבין עולם הדומם לעולם החי. במקרה של כדור הארץ, נראה שהיו אלה מולקולות של פולימר חד־גדילי – ארא"ר: במצבים אחרים, או על פניהם של כוכבי לכת דומים אחרים, יכולה היתה להיווצר "מולקולה בראשית" אחרת. מה שהיה מפנה את עולם החי שהתפתח ממנה לכיווני התפתחות שונים לחלוטין.

האבולוציה הכימית מתרחשת כתוצאה מת־ גובות כימיות ומשתנים מתמידים בסביבה. בכדור הארץ הקדום השתתפו ב"משא ומתן" המרתוני הזה גזים, כמו אמוניאק, מתן ופחמן דו־חמצני. חמצן תופשי (שהוא המפרק הכימי העיקרי בטבע) כמעט שלא היה באטמוספירה. עובדה זו אפשרה לתרכובות "ניסיוניות" רבות להתקיים די זמן וליצור ריכוזים הדרושים לקיום יחסי גומלין ביניהן.

התגובות (ריאקציות) הראשונות התחוללו, ככל הנראה, בימים הרדודים והמתייבו בחום השמש. הימים הכילו ריכוזים מקומיים של חומרים אורגניים (מכילים פחמן) מסוגים שר־ נים, וכן גופרי חרסית, שהיא חומר בעל כושר ספיחה גבוה.

ההנחה היא, שגרגרי החרסית ספחו אליהם חומרים שונים (אורגניים ולא אורגניים), ובכך יצרו ריכוז מקומי של חומרים שהגיבו אלה עם אלה ויצרו תוצרים שונים, עד שאחד מהם קם וצעק – אאוריקה.

האיש שידע יותר

לבקש

הבוקר שאחרי ההסכם: שבחים לכל הצדדים

– מאת חיים שיבי, כתבנו בוושינגטון וכתבי סוכנויות הידיעות –

בבוקר שאחרי, התקשורת האמריקנית מעניקה ציונים ל„מוסף" לחיצת הידיים של רבין וערפאת, ולעצמה, כמי שהסיקה את האירוע. ערפאת מקבל נקודות רבות על כישרון דרמטי, רבין על איפוק כאוב.

בינתיים, רשימת המודים בכך שהזילו דמעה במהלך האירוע הולכת וגדלה. נכון לאתמול, הודו בבכי השחקן ריצ'רד דרייפוס, השחקן רון סילבר, ליאון ויזלטיר מה„ניו־יורק פבליק", ויועצו של קלינטון סטפנופולוס. בין המחמיאים הגדולים ליצחק רבין, על נאומו המרגש והנוגע ללב, היה גם מזכיר המדינה לשעבר, ג'יימס בייקר.

ברוב ארצות העולם, כולל מדינות מוסלמיות מתונות, היתה התגובה להסכם, שנחתם בין ישראל לאש"ף, חיובית ונלהבת. רק מדינות מוסלמיות קיצוניות וחלק ממדינות ערב גינו את ההסכם.

הקהילה האירופית אימצה בהתלהבות את ההסכם עזה ויריחו תחילה, ורואה בו את הצעד הראשון לקראת שלום במזרח־התיכון. עם זאת, שר החוץ הבלגי, וילי קלאה, אמר, כי יישום ההסכם הוא „מירוץ נגד הזמן", והזהיר מפני אלה הרוצים לטרפד אותו.

ארגון יונסק"ו הכריז אתמול, כי יעזור בחיזוק הסכם השלום בין ישראל לפלשתינים באמצעות סיוע בתחומי החינוך, המדע והתרבות. מנכ"ל הארגון, פדריקו מאיור, הכריז: „שלום בונים על בסיס אמון הדדי, המושג בעזרת חינוך, החלפת ידע טכנולוגי ומדעי וכבוד לתרבותו של האחר".

נשיא איראן, אכבאר האשמי ראפסנג'אני, גינה אתמול את ההסכם בין ישראל ואש"ף וכינה אותו „מעשה בגידה ובושה לפלשתינים, שעליו לא נעבור בשתיקה".

בכווייט, שניתקה את הקשרים עם ערפאת עקב תמיכתו בסדאם חוסיין במלחמת המפרץ, תקפו פרשני העיתונים את ההסכם. גם לוב דחתה את ההסכם, ועיתוני סוריה חזרו על הפזמון הקבוע: כל הסכם שלום עם ישראל חייב לכלול את כל השותפים.

מנהיגים יהודיים אחדים הביעו זעם על מגיבות „שלום עכשיו" באר"ב, שמיהרה להיפגש עם ערפאת. נודע, כי אחד מראשי „שלום עכשיו" נפגש עם ערפאת יממה לפני הטקס בבית הלבן ויעץ לו ללבוש חליפה ולא מדים „כדי להיראות טוב יותר בעיני דעת הקהל באר"ב". מנהיג יהודי כינה צעד זה – „מגעיל". המנהיג הוסיף: „השמאל היהודי פה מתהלך גאה וזורק לנו 'אמרנו לכם, אמרנו לכם', אבל הם שכחו, שהם התחבקו עם ערפאת כשהוא עדיין זרק פצצות".

רבים בקהילה היהודית חשים עדיין אי נוחות כלפי אש"ף וערפאת: „אנחנו מבינים, שצריך לעבוד אתם ולעשות הכל כדי שההסכם יצליח, על־ידי שיכנוע הקונגרס לסייע לפלשתינים. אבל זאת עדיין לא סיבה להתחיל להתחבק עם ערפאת", אמר מנכ"ל הליגה נגד השמצה, אייב פוקסמן.

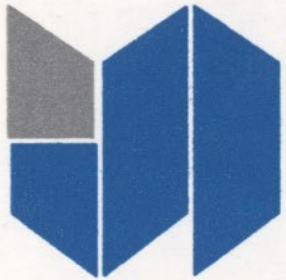
פוקסמן ומנהיגים נוספים הסתלקו במכוון מקבלת פנים, שערך הקונגרס היהודי האמריקני בוושינגטון, כאשר הגיעה ידיעה שערפאת מתכוון להגיע. ערפאת הצהיר אתמול על רצונו העז להיפגש עימם, מאחר שהוא רואה בהם ערוץ השפעה על הקונגרס האמריקני. ברגע האחרון לפני שעמד להגיע, הוזהר ערפאת, שנשקפת סכנה לביטחונו.

למרות זאת, נענו כבר מנהיגים יהודיים לבקשת הנשיא קלינטון, כי ישתפו פעולה עם הלובי הערבי בארה"ב, על־מנת להשפיע על הקונגרס להקצות סיוע נרחב לעזה ולשטחים. זאת, כדי לחזק את סיכויי הצלחת תוכנית האוטונומיה.

לחיילי צה"ל באהבה

15/9/93

פוגל ל



תיאטרון ירושלים
לאמנויות הבמה
The Jerusalem
Centre for the
Performing Arts

שלום עזרא,

כבוד מאוד שנשאר אולי לתיק
אישי, מקורי. יתכן שיהיה לי
עוד משהו?

תודה רבה רבה.

אלי נישמה 28/7

מחכה,

רחי מרכוס 20, ת.ד. 4072, ירושלים 91040, טל. 02-617167
20 Marcus St., P.O.B. 4072, Jerusalem 91040, Tel. 02-617167

Where No Artist Has Gone Be

With his energy sculptures in space, Israeli artist Ezra Orion is either brilliant or cr

SUSAN JOSEPHS
STAFF WRITER

In the vastness of the Milky Way, "Super-Cathedral I," now two light years from earth, cruises the intergalactic infinity. And its creator, Israeli sculptor Ezra Orion, remains far from satisfied.

"Super-Cathedral I" is made up of a host of energy beams launched simultaneously from points around the world — what Orion calls a "supershaft" of beams, 620 million miles tall traveling through space at the speed of light.

Artist Ezra Orion, creator of Super Cathedral I, beamed down at The UN last week.

Conceived by Orion and launched in 1992 by the European Wegener Satellite Ranging Stations in Europe, Israel and Egypt, "Super-Cathedral I" marks only the beginning of Orion's foray into what he calls intergalactic sculpture.

It is a fusion of art, geomorphology and astrophysics, "a spaceward breakthrough, reaching extreme abstraction, immense physical dimensions, light velocities and nearly eternal duration," he says. "It's about time to extend the dimensions of human sculpture to the outer ranges of the solar system."

In a slide presentation sponsored by the Department of Cultural Affairs of the Israeli Consulate in New York at the United Nations last week, Orion worked to gain support for future raeli audience. "Ezra is not following any known, conventional school. I think he is doing a wonderful job and I want to thank him for his daring."

Orion, an intense man of few words and thunderous tone, seems like an incarnation of an Ayn Rand hero like Howard Rourke or Henry Reardon.

On this planet, Orion, a resident of Kibbutz Sde Boker in the Negev, has developed a reputation for constructing massive staircases, towers and other monumental works of concrete and steel, often in the desert wilderness. A fascination with mountain summits led him to create a staircase of stone in the Annapurna Sanctuary Basin in the Himalayas, 13,200 feet above sea level.

But the Himalayas ultimately did not prove high enough for Orion. "In our essence is a strong yearning for reaching beyond the given," Orion told The Jewish Week. So "after the Himalayas — the solar system."

Orion met with astrophysicists in Israel and contacted NASA to discuss whether his ideas of intergalactic sculpture could actually be implemented. "I asked whether we can extend the term 'sculpture' to mean the shaping of energies with technology and ideas along the axis of space and time," recalls Orion. "They just smiled at me and said 'why not?' "

But after realizing that Orion meant business, scientists, engineers and technicians around the globe participated in the launching of "Super-Cathedral I." As Phillip Leider, a professor of art history at the University of California at Irvine and The Bezalel School of Art in Jerusalem observed: "The needs of the technical community and the needs of the artist meet in this work."

But Leider adds, "Orion has his own agenda to fulfill ... driven not by history of space exploration, but by the history of art."

Leider surmises that Orion's intergalactic sculpture realizes the vision of modern art pioneers like Malevich, Kandinsky and Mondrian, who all "speculated on an ultimate work of art that would free the artist once and for all from his dependence on matter," he said in a speech at Israel's Bar-Giora Observatory in 1992, during the launching of "Super-Cathedral I." Orion's work "is consistent ... with the greatest aspirations of modern art from the ear-

Spaced Out: Orion's space sculpture was launched from satellite s Egypt.

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From Orion's earliest moments — he was born in 1934 on Kibbutz Beit Alfa — it seems that a "universalism, a Jewish Marxism, the pioneering spirit of the kibbutznik and a belief that history is moving towards an egalitarian society" governed his life. By the age of 5, Orion had discovered he could draw — pictures of lions, bulls and Bar Kochba fighting the Romans. As he got older, "rocks taller than me," desert landscapes and mountain peaks would be strong, consistent sources of inspiration. "From the start, I had the freedom to be

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res in space, Israeli artist Ezra Orion is either brilliant or crazy —or both.

raeli audience. "Ezra is not following any known, conventional school. I think he is doing a wonderful job and I want to thank him for his daring."

Orion, an intense man of few words and thunderous tone, seems like an incarnation of an Ayn Rand hero like Howard Rourke or Henry Reardon.

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And he doesn't plan to stop with his first foray into space. He has a list of projects he wants to complete by the year 2020: the launching of "Super-Cathedral II" on April 16 in the year 2000; the execution of robotic sculpture on Mars by the future Mars-Rover spacecraft; the launching of "Super-Cathedral III" by laser ranging stations on Earth, Moon and Mars in 2019, and the launching of "Super-Cathedral IV" the following year, when Mars is on the same axis as the sun.

Spaced Out: Orion's space sculpture was launched from satellite stations in Europe, Israel and Egypt.

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Orion attended the Bezalel School of Art in Jerusalem and gave his first one-man show in 1963, which featured 30 rocks welded together. In 1980, Orion completed "Staircase," the work that made him famous. On display in a Jerusalem neighborhood, "Staircase," a 60-foot structure of reinforced concrete, rises towards the heavens and evokes the biblical Tower of Babel.

In fact, the same might be said for the monumental towers that Orion constructed after "Staircase." The Tower of Babel "is a very deep and authentic myth," says Orion. But "the story's message is a failure. It says never try to get beyond your final existence, just be a good boy, be obedient. What for? For what judge?"

The notion of God has no place in Orion's understanding of the universe. "God was produced in the studios of man, therefore God belongs to the human history of ideas," he says. "It's about time that we free ourselves for the third millennium, to be an open, humanistic, truly global society."

Into that third millennium, Orion will continue to construct his towers whatever form or non-form they may take, taking Descartes' understanding of the human being one step further: "I break through, therefore I am," he says. □

ההולמים את תיאורו. גולדין התקשר בעצמו אל הנשיא ביל קלינטון ואל סגנו אל גור, עם החדשות על המימצאים. נמסר כי השניים קיבלו את הבשורה בהתרגשות.

התגלית מסעירה לא רק את הקהילה המדעית ברחבי העולם. היא הפכה לסיפור החם ביותר באמריקה. אם בשלב מסויים נוצרו חיים על המאדים, נאמר בשידורים כאן שוב ושוב, הרי כמעט ואין מנוס מהמסקנה, שהיתה עד כה נושא לאלפי ספרי מדע־בדיוני: אנחנו לא לבד. או כפי שהגדיר זאת אתמול האסטרונום ג'פרי מרקי מאוניברסיטת סן פרנסיסקו סטייט: „זו יכולה להיות התגלית הגדולה ביותר של המאה. זה אומר שחיים אינם איזה מקריות משונה, שקרתה רק בכדור הארץ".

הביולוג הבלגי כריסטיאן דה־דוב, חתן פרס נובל, מומחה לחיים ביקום: „ברור שאלה חדשות מרגשות מאד, אבל אינני רוצה להגיב לפני שיהיה בידי מידע נוסף". דה־דוב אמר כי „אחת השאלות העיקריות היא: אם היו חיים על המאדים – האם היו אלה חיים שדומים לחיים על כדור הארץ". הוא הוסיף: „איננו יכולים לשלול את האפשרות, כי החיים הגיעו לכוכב שלנו מהמאדים, או שהם עברו מכאן למאדים דרך מטאוריטים, שנשאו בקטריות בעלות כושר שרידות גבוה".

„אותי זה לא מפתיע מאוד", אמר אתמול פרופ' איליה לייבוביץ', מנהל מצפה הכוכבים ע"ש וייז במצפה רמון, השייך לאוניברסיטת תל־אביב. „אני לא חושב שמה שהתרחש על פני כדור הארץ שלנו הוא משהו חד־פעמי, שיכול להתרחש רק על כדור הארץ". לייבוביץ' הוסיף, כי לפני שנה התגלו מחוץ למערכת השמש שלנו עוד שלוש או ארבע שמשות, במרחק עשרות שנות אור מאיתנו. מסביב לכל אחת מהשמשות יש פלנטה שלמה, דומה לפלנטה שלנו, וייתכן שגם בפלנטות אלו נוצרו חיים.

כבר עתה ברור, כי בשנים הקרובות צפויה פלישה של האדם למאדים, בניסיון לגלות כל מה שניתן על ה„חיים" שם. במאמצים אלה תככב נאס"א, אבל לא רק היא.

ויש גם מי שאינם שותפים להתלהבות. אנשי נאס"א, שהעריכו כי יידרשו עוד מחקרים ועוד שיגורים למאדים, כדי לעמוד על משמעויות התגלית, וגם מדענים אחרים, שאינם בטוחים כי ניתן להגיע מהמימצאים למסקנות חותכות. „המסקנות הן במקרה הטוב מוקדמות מדי וככל הנראה מוטעות", אמר אתמול ל„ידיעות אחרונות" מדען הכוכבים ג'ון קריג' מאוניברסיטת קליפורניה. ובכל זאת אין ספק, כי התגלית תורים כספים רבים למחקרים נוספים ולמימון שיגורים חדשים למאדים.

ובאנגליה הודיע אתמול סוכן הימורים זרין, כי הסכירות בהימורים אצלו גדלה להימצאות חיים אינטליגנטיים מחוץ לכדור הארץ, בעקבות גילויי נאס"א. היל מציע להמר 25 לאחד נגד חיים כאלה, לעומת 500 לאחד בעבר.

השרידים נתגלו בתוך סלע נעשי ממאדים, שהדרך לכדור הארץ כמטאוריט לפני 13 אלף שנה, ונמצא באנטרקטיקה לפני תריסר שנים.

המטאוריט עצמו, שבו נתגלו המולקולות הוא בן 4.5 מיליארד שנה. רק לפני שנת־יים גילו המדענים בוודאות, כי המטאוריט, המכונה „84001 בלט", אכן הגיע מהמאדים, בתהליך המתואר בתרשים מימין.

תחת מיקרוסקופים אלקטרוניים משוכללים ביותר שפותחו באחרונה, התגלו במטאוריט החדשות הגדולות: „מבנים זעירים ביותר, חד־תאיים, שדומים לפעילות של בק־טריות על פני כדור הא־רץ", כפי שהגדיר זאת מנהל סוכנות החלל האמריקנית, דניאל גולדין. במילים אח־רות: החומרים הללו העידו על אפש־רות קיומה של פעילות ביולו־

הנקודה הישראלית

תוכנית: פסל ראשון על המאדים

סוכנות החלל הישראלית מסייעת לפסל הישראלי, תושב שדה בוקר, עזרא אורין, בתוכניתו להקים את הפסל הראשון על המאדים.

לפי התוכנית של אורין, שהועברה לסוכנות החלל האמריקנית, כאשר אחת החלליות הקרובות תנחת על המאדים ותוציא רכב בלתי מאוייש כדי לקחת דגימות קרקע, יבצע הרכב הזה גם משימת „פיסול", לאחר השלמת הניסויים המדעיים.

הרכב יאסוף סלעים מפני המאדים, ויסדר אותם בצורה מסויימת, על פי תוכנית של אורין.

„אנחנו מסייעים לאורין בקשר עם סוכנות החלל האמריקנית", אמר אתמול אבי הראבן, מנכ"ל סוכנות החלל הישראלית.

הראבן אמר, כי בעבר היו מומחי הסכניין שותפים למאמצי הפיענוח של חלק מן המימצאים שהגיעו מהמאדים. „כיום אין לישראל כל מעורבות במחקר בנושא מאדים. זהו מחקר טהור, ואילו אנחנו עוסקים במחקר יישומי", אמר הראבן.

יומן מסע

ממרינר ועד ויקינג

• 1964 – החללית האמריקנית „מרינר 4" הולפת ליד המאדים, מצלמת אותו, ומשדרת לכדור הארץ צילומים של פני הכוכב באיכות סבירה.

• 1969 – החלליות „מרינר 6" ו„מרינר 7" שולחות שתי סדרות נוספות של צילומים.

• 1971 – „מרינר 9" חללית ראשונה שלא רק חולפת ליד המאדים, אלא מקיפה אותו כדי לצלמו מכל עבר.

• יולי 1976 – „ויקינג 1" נוחתת על המאדים ונוטלת דגימות קרקע, בין היתר בניסיון לגלות סימני חיים.

• אוגוסט 1976 – החללית „ויקינג 2" נוטלת דגימות דומות.

אריה אבוזי

• יום ולילה: די דומה למצב אצלנו. יממה – 24 שעות, 50 דקות ו־30 שניות.

נתונים: פרופ' אילה לייבוביץ'

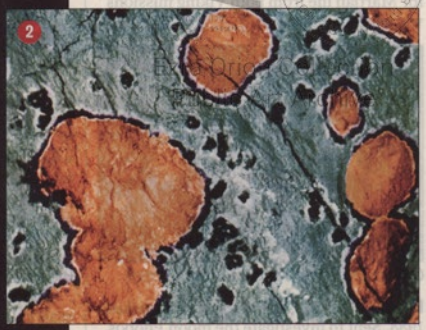
Fourth rock from the sun:
Home planet of ALH84001

UNITED STATES GEOLOGICAL SURVEY — NASA

A meteorite from Antarctica bears traces of primitive life that may have existed on Mars billions of years ago. Perhaps we are not alone. BY ADAM ROGERS

ome in, Mars

SINCE HUMAN BEINGS FIRST looked into the face of the universe and saw only infinite night, we have wondered who was out there. Not what—that was clear enough. Stars, maybe rocks like the one under our feet. But did anything laugh and cry, have children, build monuments? Was anything looking back wondering the same things about us? Those questions remain unanswered, but last week a team of scientists announced that after two years of staring into a 1.9-kilogram meteorite from our neighbor planet Mars, they had found indications of life. The microscopic organisms they say they found never experienced life the way we do. But if they're right, then more than 3 billion years ago they lived—fed, reproduced, died. And the simple fact of their existence radically improves the odds that we are not alone in the universe.



A High-Tech Hunt for Life

Sparked by a lucky meteorite find, scientists used lasers, electron microscopes and detective work to tease out signs of Martian life from 3.6 billion years ago.

1 **The courier:** The fist-size rock, one of the 12 Martian meteorites, is riddled with cracks where water flowed and microbes may have thrived.

2 **Slice of life:** Complex molecules turned up in carbonate globs, gold in this electron-microscope image. Crystals in the dark rims resemble earthly bacterial residue.

3 **E.T.?** Tubular forms, only 1/1000 the width of a hair, resemble ancient earth fossils, only smaller. Scientists are trying to slice one open to look for cell structure.

Voyages to the Red Planet

Until the 1960s, the human conception of Mars was limited to what scientists could see through telescopes and what novelists could imagine. Then the space race began. Mars became the best target for interplanetary travel. Highlights from 34 years of missions:

NASA

Mars from the approaching Viking 1

Mars 1 *U.S.S.R., flyby, launched: 1962.* The first Mars probe to successfully leave Earth's orbit failed when communications with the craft were lost en route.

Mariner 3 *U.S.A., flyby, launched: 1964.* The craft was lost when solar panels failed to open.

JPL

Mariner 9 on its way

Mariner 4 *U.S.A., flyby, launched: 1964.* The first successful Martian flyby passed within 9,920 km of the planet and returned 22 close-up photos showing a cratered, desert surface.

JPL

Successful Mariner 4

Mariner 6 *U.S.A., flyby, launched: 1969.* Passed within 3,400 km of Mars and returned video of the equatorial regions. Also sent back surface-temperature and atmospheric pressure measurements.

Mariner 7 *U.S.A., flyby, launched: 1969.* Passed over the southern hemisphere, returning about 200 photos.

Mars 2 *U.S.S.R., orbiter/lander, launched: 1971.* The lander crashed during a dust storm, creating the first human artifact on Mars.

Mars 3 *U.S.S.R., orbiter/lander, launched: 1971.* The first successful landing on Mars, it transmitted 20 seconds of data until contact was lost in a dust storm.

Mariner 9 *U.S.A., orbiter, launched: 1971.* The first U.S. craft to orbit another planet, it mapped 85 percent of the surface. It also returned the first high-resolution images of Martian moons Phobos and Deimos.

Mars 4 *U.S.S.R., orbiter, launched: 1973.* The craft failed to go into orbit due to a braking-rocket malfunction. It returned only a few images as it passed the planet.

Mars 6 *U.S.S.R., orbiter/lander, launched: 1973.* Contact with the lander was lost 148 seconds after the parachute opened, just before touchdown.

Mars 7 *U.S.S.R., orbiter/lander, launched: 1973.* The landing mission was lost when a braking- rocket failed, causing the spacecraft to miss Mars by 1,300 km.

Viking 1 *U.S.A., orbiter/ lander, launched: 1975.* The first U.S. soft landing on another planet, it returned 26,000 images and discovered the presence of water ice in the polar caps.

Viking 2 *U.S.A., orbiter/lander, launched: 1975.* Immense return of data and images from both the lander and orbiter. The craft also detected the presence of argon and nitrogen in the atmosphere. Tests for Martian life from both Viking missions were inconclusive.

NASA

Constructing the Viking 1 landing craft

Phobos 1 *U.S.S.R., orbiter/lander, launched: 1988.* Sent to investigate the moon Phobos. Lost when a bad command caused the craft to point its solar panels away from the sun.

Mars Observer *U.S.A., orbiter, launched: 1992.* The most recent craft to visit Mars was to conduct high- and low-resolution imaging of the planet, surface analysis and weather monitoring. But communication was lost on August 21, 1993, just before it was to be inserted into orbit.

NASA

Mars Observer

SOURCE: NASA HISTORY OFFICE, AD ASTRA MAGAZINE. RESEARCH BY BRAD STONE.

The scientists working on the meteorite rushed to acknowledge the circumstantial nature of their evidence: a few complex molecules, crystals that look like those produced by bacteria here on Earth and tiny tubes that look like terrestrial fossil bacteria. Any single finding could be refuted, but taken together they were enough for the National Aeronautics and Space Administration to call a press conference last Wednesday, and for NASA administrator Daniel Goldin to brief the president and members of Congress on the possibility of life in outer space. "We're not here to establish as in a courtroom beyond a shadow of a doubt that life existed on Mars," said Goldin. "We're here to open the door, to provide exciting scientific findings, to tell a fascinating detective story and to lay out compelling clues that lead us in the direction that we think life might have existed at some point on Mars." That only added to the hoopla caused by a draft copy of the scientists' research leaked to the press well in advance of its publication in this week's issue of the journal Science John Pike, the director of space policy for the Federation of American Scientists, gave his own modest assessment: "This is the biggest thing that has ever happened."

A RECOVERY TEAM FOUND THE softball-size meteorite in 1984 while on an annual National Science Foundation mission to Antarctica, in the icy wasteland of the Allan Hills. Its designation, ALH84001, reflects that origin. But the meteorite's journey began 4 billion years earlier, when it was part of the crust of Mars. (Scientists know this because when the rock is heated, it still gives off a mix of gases unique to the Martian atmosphere.) The planet was a very different place then—the air was about as thick as Earth's, the temperature was about the same and liquid water flowed on or near the surface.

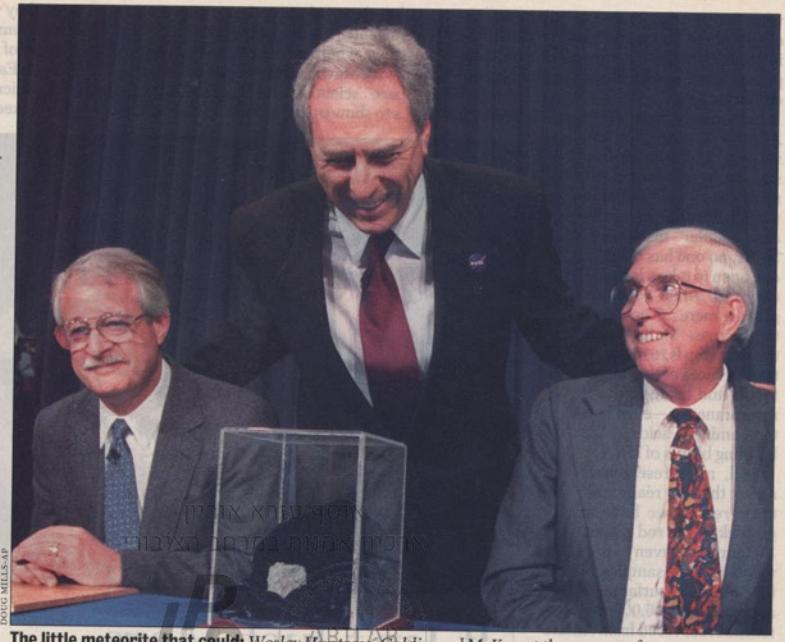
About 3.6 billion years ago, blobs of minerals called carbonates were forming inside tiny cracks in the rock, spreading like hard-water deposits in pipes. Over time, Mars lost its atmosphere and liquid water vanished. Perhaps 15 million years ago, an asteroid or comet slammed into Mars and kicked up the clump of crust that would eventually become ALH84001. It orbited the sun until 13,000 years ago, when it plunged into the Antarctic—where it remained until it was found 12 years ago.

From this unprepossessing chunk of rock, scientists have teased out a remarkable chain of evidence leading toward an astonishing conclusion. Team member Richard Zare, a chemist at Stanford, used lasers and an extremely sensitive detector called a mass spectrometer to spot mole-

cules called polycyclic aromatic hydrocarbons. PAHs result from combustion; they are found in diesel exhaust and soot, even in many other meteorites. But they also come from the decomposition and fossilization of living organisms. The residue in ALH84001, says Zare, "very much resembles what you have when simple organic matter decays." The PAHs are deep inside the fissures in the rock, and their concentrations are much higher than in Antarctic ice. Both of these facts strongly suggest that the PAHs came from Mars, not from outer space or Earth.

The team also needed to know whether the PAHs came from living things. The concentration of PAHs was highest near the carbonate globules, so the researchers put them under another high-tech sensor, an ultrahigh-resolution transmission electron microscope. They found that the thin black-and-white bands at the edges of the carbonates were made of mineral crystals 10 to 100 nanometers across (the period at the end of this sentence is about 500,000 nm wide). Like PAHs, these minerals—mainly iron compounds called magnetite and pyrrhotite—can come from inorganic sources. But the crystals in the meteorite were shaped like cubes and teardrops, just like those produced by bacteria on Earth. In other words, they look like bacteria droppings.

The finding that transfixed researchers all over the world, though, was also the most vivid. Using a scanning electron microscope, which can resolve nanometer-scale details in three dimensions, David McKay and Everett Gibson of the Johnson Space Center focused on grains at the edges of the carbonate globules. "Some of these don't look like either magnetite or iron sulfide," McKay says. At the press conference, McKay showed a slide not included in the Science article. It's of a cluster of elongated, tubular shapes with rounded ends. The smallest is about 20 nm long; the largest, around 200 nm. "Are these strange crystals? Are they dried-up mud?" McKay asks. "We interpret that these are indeed microfossils from Mars." As the carbonate deposits formed, they seem to have trapped these presumed microorganisms like bugs in amber. Comparisons with terrestrial fossils are equivocal. Pictures of 3i- billion-year-old bacteria from our planet look similar to those of the Martian variety, but they are as much as 100 times larger.



DOUG MILLS-AP

The little meteorite that could: *Wesley Huntress, Goldin and McKay at the press conference*

'We're here ... to tell a fascinating detective story and to lay out clues that lead us in the direction that we think life might have existed on Mars.'

The scientists, and NASA, are doing all they can to avoid another cold-fusion debacle, announcing a "breakthrough" at a press conference only to have it debunked. "We have these lines of evidence," McKay says. "None of them in itself is definitive, but taken together the simplest explanation is early Martian life." At their press conference, McKay's team pressed the need for further confirmation of their results. Other scientists agreed. "It is provocative evidence," said astronomer and author Carl Sagan. "It is not yet at the level where we can definitively say that microfossils have been found on Mars ... but I think some guarded optimism is quite realistic."

Some scientists in the field express more optimism than others. William Schopf, a paleobiologist from the University of California, Los Angeles, who has studied ancient life on Earth for three decades, called the news of life on Mars "an extraordinary claim." He warned that "the mere presence of organic matter by itself does not say it's part of life, because we know on this planet prior to the origin of life, organic matter was synthesized nonbiologically." Ralph Harvey, a geologist at Case Western Reserve University, and Harry McSween Jr., a geologist at the University of Tennessee, have also studied ALH84001. In a paper in the journal Nature last month, they said that the carbonate globules formed at temperatures greater than 650 degrees Celsius, much too hot for any life we know of to exist. "None of us have really convinced each other how these carbonates formed in this rock, and that should be a warning sign," says Harvey. He ought to know—his office was next door to Gibson's this summer.

Every scientist familiar with this field of research, including McKay's team, knows that alternative explanations exist for all the team's data, each more mundane than Martian bacteria. "The question is whether each of the processes that might have made the magnetites and the organic molecules might have happened no matter

what," says Allan Treiman, a planetary geologist at the Lunar and Planetary Institute in Houston, "and whether all of them happnings more or less likely than having microbes in there."

Fortunately, most of the questions about ALH84001 can be answered. If the microfossils are in fact long-dead microbes, the remains should include cell walls and cellular machinery. So far, no one has cracked one open to take a look, no easy task when your target is a mere 20 nanometers across. McKay says the next step is to make ultrathin slices of the microfossils and try to find cell membranes or—even better—amino acids, the building blocks of DNA.

Still, most researchers agree that to really test these results we have to go back to the red planet. Meteorites haven't provided enough samples of the Martian surface—of approximately 15,000 meteorites recovered from Antarctica, only 12 come from Mars. The latest find has renewed calls by space advocates for a manned mission to Mars, which was originally advocated by the National Commission on Space in the mid-'80s and then embraced as a long-range goal of the Bush administration. But some scientists believe sending Earthlings to Mars would be a calamitous mistake. "The last thing you would want is to have men there, copiously contaminating Mars and ruining it forever," says Cornell astronomer Thomas Gold.

Instead, NASA is planning 10 robot missions to Mars over the next 10 years—"an armada of spacecraft," says Goldin. The Pathfinder, set to launch in December, is scheduled to land an automated rover on the surface on July 4, 1997. It's a tricky process, though. The most recent try, the Mars Observer, disappeared just before making orbit in 1993, and the latest Russian probes have also failed. Mars experts have been burned by robot probes of the surface, too. In 1976 early results from the Viking landers seemed to show life in the sand and turned out to be wrong. As a result, scientists believe that "sample return" missions, where probes go to Mars and return with Martian soil, will be decisive.

Space scientists have been expecting E.T.s to show up for a while. In the past two years they've found seven planets in other star systems. And one of the emerging discoveries of terrestrial biology is the tenacity of life on Earth. Just about anywhere there is water, microbial life can thrive. Indeed, biologists keep finding colonies of bacteria in

DAVID JEFFREY—IMAGE BANK

Earth from space

It Isn't Just Mars That Will Never Look the Same

Earthlings will have to change the way they think about their planet

By Oliver Morton

The first great gift of the space age was not a breakthrough technology, or a scientific discovery, or a geopolitical victory. It was an image. Traveling to the dead dust of the moon, the Apollo astronauts sent back a picture of Earth. It has now been worn into cliché by endless use, but it retains an amazing power to move. They showed us all our homes and histories, all that we care for wrapped up in a single bright swirl of white and green and brown and blue. It was beautiful, and it was ours, and it was alone. The rest of the universe was an infinity of empty velvet blackness setting off the mother of all pearls.

Last week that changed. Now we have news of other pearls, tiny carbonate globules that seem to have been thrown to us from another world. Little Mars, arid, frozen and all but airless, bleached by ultraviolet light and pummeled by asteroids, will never look the same again. Life's span there may well have been short, it may never have amounted to much by comparison with the richness of life on Earth, and it has almost certainly been over for billions of years. But if there was once life on Mars, it changes the way we think about that planet forever. And the way we think about this one, too.

The science of life elsewhere—exobiology—was up until now entirely theoretical. It has suddenly become empirical. There will now be a mad rush for the sister meteorites from the same source that have fallen to Earth. If their study does not move the state of the evidence for Martian life from compelling to conclusive, then space probes may.

Mars will not be the only place examined afresh. This week NASA will reveal new pictures of Jupiter's moon Europa. Beneath its icy surface there may be a sunless ocean warmed by hydrothermal springs. If there is, then who is to say that the Europan abyss is a worse bet for life than the early muds of Mars and Earth? And in the past year we have seen the first proof of planets around other sunlike stars. Hugely ambitious arrays of telescopes might be able to find chemicals that seem to indicate life in their atmospheres before today's newborn chil-

the most inhospitable places on Earth, such as in rocks 1,500 meters beneath the Columbia River in Washington, or around undersea volcanic vents at 315 degrees Celsius. The threshold question in SETI—the search for extraterrestrial intelligence—is whether the evolution of life on Earth was a one-time event or the inevitable outcome of conditions that could exist on other planets. Any evidence of life on another planet, even as humble as microbes, dramatically improves the numbers in the Drake Equation, which estimates the number of intelligent civilizations in our galaxy. "The Mars discovery confirms the origin of life is easy, and will occur on planets where conditions are suitable," says Frank Drake, creator of the equation and president of the SETI Institute.

So why the fuss over life that is 3.6 billion years old? Even if they turn out to be Martian microbes, they are long dead. The universe seems quiet again. But two kilometers under the Martian surface, say some scientists, is liquid water at a temperature capable of sustaining life. And if there were microbes under Mars billions of years ago, sky watchers like Drake wonder, what exists now? "If life once thrived in the Martian subsurface, I would be surprised if it weren't there today," says Jim Fredrickson, head of the subsurface-microbiology program at the Department of Energy's Hanford site in eastern Washington. This search for answers, whether through religion, science or philosophy, is ultimately the search for our context, for our place in the universe. In the end, we don't want to stand alone.

With Mary Hager in Washington, D.C., and Peter Burkholder in New York

dren get their college degrees.

If we choose to explore, our exobiologists will discover the extent of life in the universe, and we will change the way we see our world. At various times and in various cultures humanity has filled the heavens with divine life. In this century, in which we have for the first time seen the heavens as they actually are, and started our travels across them, we have found the universe majestic but empty. We have seen our blue and green world as all there is, populating the surrounding darkness only with fantasies of the other, alien dreams and nightmares.

In some ways, it has been a salutary belief. The sight of the isolated Earth; the conversations that can span the globe; discovery of the genetic code that binds all life together; the real risk, if not proven fact, of man-made global changes: all these have, in their way, helped some of us toward a new consciousness of what a planet is. In caring about the world's environment, people have expanded their notion of who we are to include all that lives with us on the third rock from the sun.

Now we have the chance to expand that idea yet further. The Earth is an island—but if the galaxy is rich in life then we who live on it are, in John Donne's words, part of the main. The atoms of our bodies were forged in distant suns. It is even possible that Earth's life itself began elsewhere. Meteorites provide a slow, infrequent transit system between planets, as this week's find makes clear. If life began on Earth, it might have been splashed onto the face of Mars, and the fossils may be homecomers. At the same time, there is no reason why it should not have been on Mars, or even some other place, that the life we know first began. It may be some time before we know whether we have found in the fossils long-lost relatives or close neighbors. But whichever turns out to be the case, our living environment now reaches beyond the sky. To know that there is life elsewhere is to feel a new, liberating, limitlessness.

And there is only one way to know for sure. That is to go there. Not because humans would be much better at spotting and analyzing Martian fossils than machines (though they would be). But because awe-inspiring though the image of Earth alone in space may be, it has always been tinged with a sense of loneliness.

NASA—AP

Skimming the surface: *A view of Mars from Viking 1*

The rest of the universe was an infinity of empty velvet blackness ... Last week that all changed.

Every three years enthusiasts gather in Boulder, Colorado, to discuss the exploration and colonization of Mars, and to wonder how to convince the world it would be worthwhile. After this year's Case for Mars conference finished a few weeks ago, I climbed up into the hills, away from photographs of airless desert and into a world of woods and streams and dragonflies. I walked over rocks that had once been sea floors, breathing air that was breathed by dinosaurs, in light that takes a million years to bubble up from the core of the sun. I sat in a cooling breeze and wondered: does it really matter? Would this twilight meadow really feel different, better, for the simple knowledge of life beyond this wonderful world, life tied to us by common descent or common feeling or common destiny?

The thin crescent moon rose above the sandstone crags. It was dawn in the Sea of Tranquillity, where 27 years ago that day Neil Armstrong had looked down on all the life that anyone knew of, save three brave men. Yes, I thought. To feel as much part of that grander universe as I feel part of the living planet of my birth would be magnificent. This week I found that I was right. To look at the sky and know of its life feels good. To know that other minds, human or otherwise, were looking back with the same feelings—that would be transcendent.

Morton *is editor of Wired UK.*

Sacred Realms: God's Expanding Universe

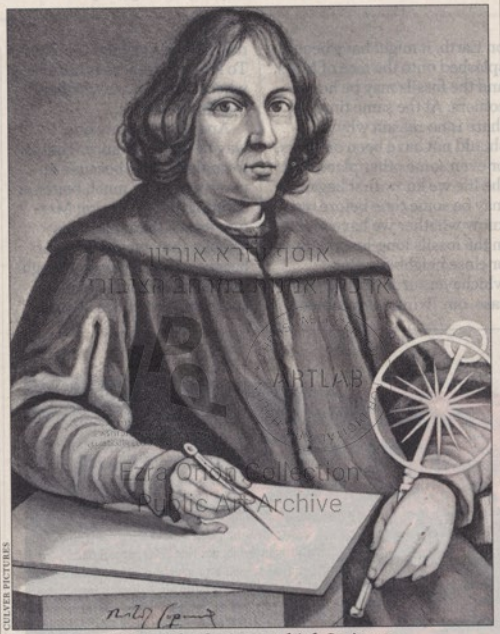
The Mars discovery excites religious thinkers

By Kenneth Woodward

Copernicus, Galileo, Darwin: the history of science is studded with discoveries that have made theologians rethink what the Scriptures say about the creation of the universe. The evidence introduced last week that microbes may well have existed on Mars, more than 4 million years ago, hardly disturbed the universe of faith. But it did excite the imagination, especially of scientists who are also religious believers.

At the papal summer residence, where John Paul II was vacationing with a group of philosophers, astronomers from the Vatican Observatory were elated by the prospect of life outside planet Earth. "Finding life on other planets is a vindication that God is not limited by our imagination," said Jesuit Guy Consulmagno, a specialist on meteorites. "As our understanding of creation grows, our understanding of God gets bigger." At the Harvard-Smithsonian Center for Astrophysics, astronomer Owen Gingerich, a conservative Protestant, put the Martian find in Biblical perspective. "In Genesis there's a kind of sacred story being told that focuses on us. But within that focus there is nothing that precludes intelligent life elsewhere in the universe. It would be extremely arrogant to limit God's creativity to human beings as the only contemplative creatures in the universe."

To be sure, it is a long way from a handful of molecules to intelligent beings with a will and conscience. There is, in fact, still no evidence to suggest that humankind is not alone among billions of galaxies. But to an astronomer like David Slavsky, dean of science and mathematics at Loyola University in Chicago, and a religious Jew, the message from Mars offers profound intellectual reassurance. "It tells us that the laws of physics and chemistry are not limited to Earth alone," he says. "I find it intellectually and spiritually uplifting to have evidence that these laws apply throughout the universe. It would be plain pre-Copernican to believe that life cannot occur anywhere else."



COLVER PICTURES

Copernicus: *Making theologians rethink Scripture*

'Finding life on other planets is a vindication that God is not limited by our imagination,' says a Vatican astronomer

If the laws of life are uniform throughout the universe, what about the laws of God? For Hindus and Buddhists, there is no problem: their cosmologies already teem with alternate universes inhabited by celestial and other beings. But the religions of the Bible clearly have theological questions to consider. Does the revelation of God on Mount Sinai apply to beings from another planet? If Christ died for the sins of a fallen humankind, would his death redeem beings from a distant galaxy? And must Muslims wage holy war with aliens to extend the community of Allah?

For the world's largest religion—Christianity—Scripture may provide a clue. The New Testament proclaims that all creation was sanctified and redeemed through Jesus Christ. The Gospel of John, in particular, presents Jesus as the Word of God who existed at the beginning of time—and, therefore, presumably of space as well. "It may be that God became incarnate in other forms elsewhere in the universe," suggests Jesuit Consulmagno. "If we were to make contact with other intelligent life, we'd have to tell our own sacred story, listen to them tell theirs and learn. But who would be the teachers, and who the learners—that we'd have to find out."

To astronomer Slavsky, the mere possibility of intelligent life elsewhere in the universe opens up a new sense of community—and an expanded notion of sacred drama. "We already have a different sense of community than that which existed 5,000 years ago," he says. "Today it means everyone on this Earth. Someday I hope we can extend that sense to a community of the universe." And what about God? Perhaps the Lord's reproving words to Job, his protesting faithful servant, will still inspire awe. "Where were you when I laid the foundations? Tell me, if you understand."

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18/10

AND MUSIC

— *Images of the ISY* —

SPACE ART FESTIVAL PLANNED FOR CANNES

The European Association for the International Space Year (EURISY) has announced plans for an international festival celebrating the arts and space early next year in Cannes on the French Riviera.

The 1st International Festival of "The Arts and Space" will feature exhibits of paintings and sculpture, books and periodicals, films and photographs, as well as colloquia with artists and scientists.

"This festival is the first of its kind and will add an enriching dimension to a year of important scientific activity," said Jacqueline Gomérieux, Secretary-General of EURISY, which is based in Paris and includes Europe-wide membership.

"We want to

Young viewer examines space art by Don Maitz, Bryn Barnard, and Frank Kelly. (photo by

of the annual Cannes Film Festival.

Its main components include a festival of 12 feature-length films, a program of more than 100 original film documentaries produced by space agencies and aerospace firms, an animated cartoon festival, a photo exhibition, an exhibition/contest of children's drawings, a painting and sculpture exhibit, a literary exhibition, and a philatelic exhibition.

Mrs. Gomérieux added that the conference will feature panel discussions and other public events involving artists and scientists that "will stimulate interaction among representatives of these equally creative perspectives."

The festival will conclude with a tele-

"Art of the Cosmos" exhibit includes these images by Jean Michel Joly (right and left) and Wolfgang Gersch (center) (photo by Brian Sullivan, Hayden Planetarium)

ART OF THE COSMOS

When most people think of space exploration, renditions of space art probably pop into their heads — ultra-realistic scenes of spaceships hovering over barren moons, distant galaxies lighted by flaming suns.

A collection of such stellar images is on display in a traveling ISY exhibit called "Art of the Cosmos," which opens in September at the Discovery Museum in Bridgeport, Connecticut. It premiered last November at the Hayden Planetarium of the American Museum of Natural History in New York, where it was the largest art show the planetarium had ever displayed.

With more than 70 paintings by 39 astronomical artists, "Art of the Cosmos" offers a broad cross-section of personal visions of the universe based on both scientific knowledge and the imagination.

The collection was organized by the International Association for Astronomical Arts (IAAA), which represents more than 150 artists in 14 countries.

The ISY is a perfect showcase for the work of the group, said Beth Avary, IAAA Director of Exhibitions. "The artists of 'Art of the Cosmos' have found inspiration in concepts and sights that go beyond our tiny speck of a planet to include the incomprehensible immensity of the universe and our participation in it," she said. "Because of this, the work is an important tool for our understanding."

show how science and art have inspired one another in the imaginative arena of space," Mrs. Gomérieux said.

The three-day festival will be held in February at the Cannes Conference Centre, site

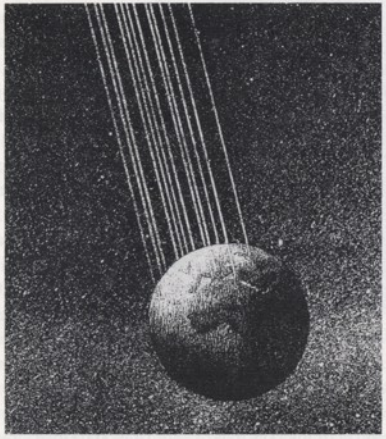
Brian Sullivan, Hayden Planetarium)

vised show at Cannes' Festival Centre amphitheatre dedicated to space research and exploration, with films, ballet, music, and personal appearances by prominent figures in government, science, and the arts.

SCULPTING THE HEAVENS

On April 27, eight powerful streams of laser energy burst from the surface of Earth into the galaxy to form an "intergalactic sculpture" dedicated to ISY 1992. This cosmic work of art, composed of parallel beams of light each one billion kilometers tall, will theoretically travel at the speed of light through the Milky Way and on into the universe indefinitely.

Proposed for the ISY by Israeli sculptor Ezra Orion, the computer-controlled laser-beam sculpture was organized by the Israel Space Agency. Laser ranging stations that simultaneously fired green and red beams for 55 minutes and 33 seconds were located in Austria, Germany, Egypt, Russia, and Spain, as well as the Israeli station west of Jerusalem that is operated in cooperation with NASA's Goddard Space Flight Center.



Artist's rendition of Ezra Orion's ISY space sculpture, showing laser beams leaving Earth

The energy beams are a sculptural message meant to fuse two ways of looking at the universe: the Eastern, mystical view of expansion into the cosmos, and the Western concept of the individual and the importance of technology. The sculpture was designed to be a cognitive experience, highlighting infinity, as well as a recognition of the human ability to perform technological marvels.

Orion describes the beams as a "super cathedral," drawn toward the skies in a continuation of the medieval cathedral.

"Today sculpture is ready for a spaceward breakthrough — reaching extreme abstraction, immense physical dimensions, light-speed velocities, and eternal duration," said the artist. "Now is the time for sculpture to extend in two dynamic environments — the solar system and the intergalactic vastness."

"Art of the Cosmos" visitors enjoy "The Ultimate Sandbox" by artist Michael Whelan. (photo by Brian Sullivan, Hayden Planetarium)

THE COSMIC SPIRIT

From time immemorial, the immensity of the universe has inspired awe. In different cultures, that appreciation takes varied forms. Sometimes, the best way to express recognition of the profound is through a simple message.

Such was the case in January, when the Buddhist Daigoji Temple in Nara, Japan, held a modest ceremony in honor of the ISY. The Association of Space Explorers, an international organization of astronauts and cosmonauts, participated in the event.

The temple's "Message to Outer Space" read, in part:

"We are very ordinary people and we live confined in the space of time. Albeit temporarily, by venturing beyond the boundaries of time... we bring ourselves closer to the environment that surrounds us...

"In this International Space Year, we pray with all our hearts to the immense outer space that knows of no boundaries."

Below: "Galactiscape," by space artist Beth Avary

שיגורו של הטיל „דלתא 2", שאליו הוצמדה החללית „גשש המאדים". היא נפרדה מהטיל כשעה ורבע לאחר השיגור אתמול, והמשיכה בדרכה עם הג'יפ הזעיר בתוכה. (תצלום: אי.אף.פי)

בדרך לסוד האדום

האמריקנים שילחו אתמול לחלל את „גשש המאדים", שתנחת על הכוכב המסתורי ביום העצמאות האמריקני • ג'יפ זעיר ייצא לסייר בשטח וישגר נתונים לכדור־הארץ • אולי נדע סוף־סוף אם יש שם יצורים ירוקים

מאת כתבי סוכנויות הידיעות,
כף קנוואראל, פלורידה

רכב־גישוש בדמות ג'יפ זעיר בעל שישה גלגלים, שגודלו אינו עולה על מדפסת־לייזר משרדית, יצא את־מול לדרך אל המאדים, מרחק של כחצי מיליון קילומטרים, במטרה לחקור את אדמתו של כוכב־הלכת האדום.

הג'יפ, המכונה „סוג'רנר" (Sojourner), נישא בתוך חל־לית ששוגרה אל החלל אתמול, מבסיס החלל בכף קנוו־ראל, בשעה 1:58 אחר חצות (08:58 לפי שעון ישראל). החללית נושאת את השם „גשש המאדים", והיא תגיע לי־עדה, על־פי התוכנית, ביום העצמאות האמריקני, 4 ביולי '97. הוצאות שיגורה מסתכמות ב־196 מיליון דולר.

אם הכל יתנהל לפי התוכנית, תחלוף החללית דרך האטמוספירה הדלילה של המאדים ותנחת נחיתה רכה על אדמתו, מוגנת על־ידי כריות־אוויר ענקיות. לקראת הנ־חיתה, תאט תוך חמש דקות ממהירות של 43,500 קמ"ש ל־48 קמ"ש בלבד.

לאחר הנחיתה ייצא הג'יפ הזעיר מן החללית וישוטט על־פני אדמת המאדים. הנחיית הג'יפ, המונע באנרג־יה סולארית, תיעשה בשלט־רחוק על־ידי צוות טכנאים של נאס"א. הג'יפ יקרין לכדור־הארץ תמונות של פני המאדים ונתונים על מבנה סלעיו.

נחיתת האדם על מאדים – ב־2008

חקר החלל

תחזית מפורטת למדי, כולל הערכה תקציבית, לקראת המבצע הגדול ביותר שידעה האנושות ומיועד לתחילת שנות 2000

מכנים אותו "כריסטופר קולומבוס של מאדים". החודש יצא לאור ספרו The Case for Mars שבו הוא מפרט כיצד לפעול כדי להגיע לכוכב הלכת המסקרן. רעיונותיו הביאו כבר לשינוי מקצה־לקצה במה שנחשב ל"פילוסופיה של סוכנות החלל האמריקנית (נאס"א)". בעבר העריכה זו כי עלות שיגור אדם למאדים תסתכם ב־450 מיליארד דולר. בעקבות מאמריו וספרו של רוברט זובריז, מהנדס טילים אמריקני בן 44, מבכירי חברת "לוקהיד מרטין", ההערכה עתה היא, שאפשר יהיה לבצע זאת בעשירית המחיר.

כבר עתה ברור כי האסטרונאוטים שינחתו על מאדים – כנראה בעוד כעשר שנים – לא יצטרכו להשתמש ב"טכנולוגייה עתידנית", אלא במה שכבר קיים. זובריז שיכנע את נאס"א שניתן לעשות זאת ושאין מחסומים שימנעו מהאדם להגיע לכוכב הלכת השכן, המרוחק מאיתנו כ־60 מיליון ק"מ. כמו כן אין צורך לבנות תחנות־ביניים בחלל, בדרך ליעד, אלא אפשר לבצע זאת בטיסה ישירה.

כן סבור זובריז שהאסטרונאוטים שיגיעו למאדים יוכלו להשתמש במה שקיים שם לצרכי שהותם על כוכב הלכת ואין צורך להביא את הכל מכדור הארץ. ניתן יהיה להפיק במאדים די דלק ולהשתמש באטמוספירת כוכב הלכת כדי להבטיח את שובם של הנחתים, לכדור הארץ.

בספרו הוא מציע לשגר כור גרעיני קטן למאדים, כדי שייצר מספיק חשמל לתיפעול בסיס הנחיתה על כוכב הלכת. מדובר, על פי חישוביו, במימן נוזלי במשקל של 6 טונות שייובא מהארץ ואילו פחמן דו־חמצני יושג מאויר מאדים. בדרך זו יופק מתאן וחמצן במשקל של 108 טונות – כמות מספקת לביצוע הטיסה חזרה. היא תימשך כשנה.

זובריז מעריך שעוד בטרם תוצג על מאדים כף רגל אנושית, יחלו לסחור בקרקעותיו. כן חישב שכרטיס הטיסה למאדים יעלה כחצי מיליון דולר.

על־פי תוכניות נאס"א, יבוצעו בשנים הקרובות עשר משימות מדעיות הקשורות במאדים, באמצעות חלליות־רובוטיות. ביולי הקרוב אמורה להגיע לכוכב הלכת גששית (או מפלסת דרך) ראשונה. סידרה זו תסתיים בשנת 2005. זובריז סבור שאם כל המידע שיושג ממשימות אלה ייאסף כראוי וינותח במהירות, אפשר יהיה לשגר את האסטרונאוטים הראשונים למאדים עוד בשנת 2008.

7/7/97

הפלישה למאדים

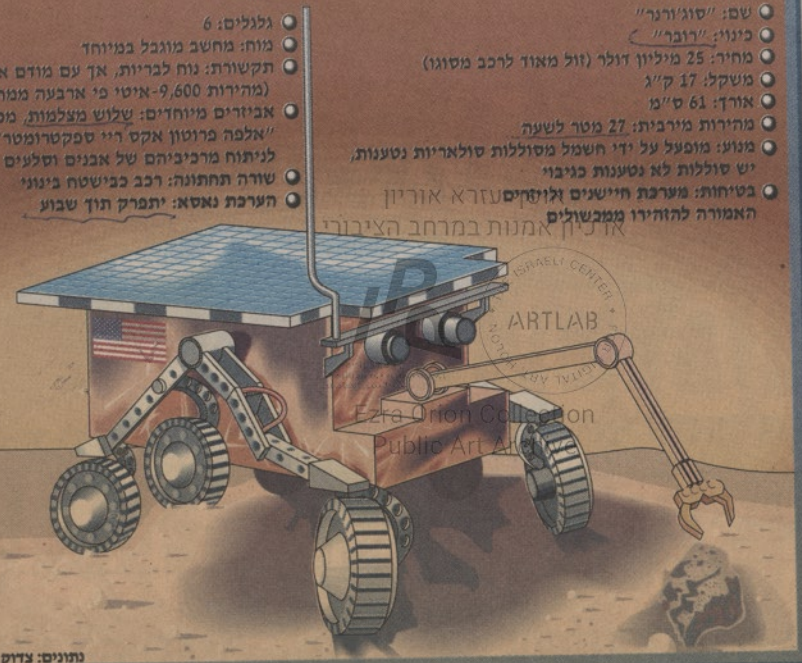
רגע הגדול: „סוג'ורנר", רכב השטח, שניות לאחר שיצא מתוך חללית האם.

(צילום: „רויטרס")

רכב השטח: תעודת זהות

מהיר כמו צב

- שם: "סוג'ורנר"
- כינוי: "רובר"
- מחיר: 25 מיליון דולר (זול מאוד לרכב מסוגו)
- משקל: 17 ק"ג
- אורך: 61 ס"מ
- מהירות מירבית: 27 מטר לשעה
- מנוע: מופעל על ידי חשמל מסוללות סולאריות נטענות, יש סוללות לא נטענות כגיבוי
- בטיחות: מערכת חיישנים וזיזקים האמורה להזהירו ממכשולים
- גלגלים: 6
- מוח: מחשב מוגבל במיוחד
- תקשורת: גוף לבריות, אך עם מודם איטי (מהירות 9,600-איטי פי ארבעה ממחשב ביתי)
- אביזרים מיוחדים: שלוש מצלמות, מכשיר "אלפה פרוטון אקס ריי ספקטרומטר" לניתוח מרכיביהם של אבנים וסלעים
- שורה תחתונה: רכב כבישטח בינוני
- הערכת נאסא: יתפרק תוך שבוע



נתונים: צדוק יחזקאלי

מדענים חוזים:

עד 2020 ידרוך אדם על מאדים

7/7/97

החל שלב ב'

„טרקטורון" על מאדים

„סוג'ורנר", רכב השטח של החללית שנשלחה למאדים, היה אתמול לכלי־הרכב הגלגלי הראשון אי פעם ששוטט על אדמתו של כוכב לכת אחר • המדענים הצליחו להתגבר על בעית התקשורת של המחשב שלו, שלא העביר נתונים לחללית האם • המודם כובה, הודלק אחרי כמה שעות, והמערכת החלה לתפקד • עכשיו מחכים לתגליות

מאת **צדוק יחזקאלי**, כתבנו בניו־יורק

האנושות עשתה אמש עוד צעד היסטורי, אבל התחילה לא היתה שייכת לאסטרונאוט, אלא למעין טרקטורון – שנראה יותר מכל כצעצוע – אשר זחל לראשונה על פני מאדים.

זו היתה הפעם הראשונה שרכב חללי משוטט על גבי כוכב אחר בשליחות האנושות. מדעני נאס"א במטה הבקרה בפסאדנה, שבעה חודשי טיסה ממאדים, הגיבו בתרועות שמחה רמות. היתה להם סיבה טובה: עברו עליהם שעות ארוכות של מריטת עצבים. רכב השטח, שנקרא „רובר" או „סוג'ורנר", אמור להעביר באמצעות מודם את הנתונים שאסף לחללית האם, ה„פת'פיינדר", ומשם אמורים הנתונים להגיע לכדור הארץ על־ידי אותות רדיו, פעולה שנמשכת 10 דקות. מסיבה כל שהיא, המודם של ה„רובר" לא תיפקד כהלכה.

המדענים עדיין לא יודעים מדוע זה קרה. אבל פיתרון הם מצאו: זה היה הטריק הכי פשוט בספר – הם כיבו את המודם, והדליקו אותו מחדש אחרי כמה שעות של מנוחה. זה פעל.

לפנות בוקר (שעון ישראל) התקבלה התשדורת הראשונה מה„פת'פיינדר", שכללה נתונים מה„רובר". בפסאדנה צהלו. תקלה נוספת שעליה התגברו, היתה הסרת המכשול של אחת מכריות האוויר שריככו את נחיתת החללית. הכרית חסמה את דרכו של רכב השטח כי לא התקפלה כיאות.

החללית קיבלה פקודה ממוחשבת להתרומם על כני הנחיתה שלה. כרית האוויר השתחררה, והדרך נפתחה.

ה„רובר" נשלח תחילה לסלע קרוב, כמה מטרים מרכב האם. הוא יוכל לא רק לצלמו מקרוב, אלא גם לבדוק את הרכבו הכימי ולשדר את המידע הביתה. המדענים מקווים, שעד שיפסיק לתפקד – תוך זמן שמוערך בין שבוע לחודש – יוכל הרכב לטרוק שטח של כמה עשרות מטרים, ולגלות עוד כמה מסודות היקום.

הסיבות למבצע

מעריב

היום מצורף מגזין עסקים

יום ג', כ"ב בתמוז תשנ"ט, 6.7.99, גליון מס' 15736, שנה נ"ב ■ המחיר 3.80 ₪ (כולל מע"מ), המחיר באילת 3.30 ₪ ■ MAARIV מעריב

מהלומה לברק: העבודה דחתה את מועמדו לראשות הכנסת, ובחרה באברום בור"ג ■ מבוכה לבורג: כשבירך אותו ברק, סינן: "שתחנק" ■ אח"כ הסביר: "בדיחה פרטית"

ממשלת ברק יוצאת לדרך

חילופי השלטון

המחלוקת בעבודה על מינוי השרים ופרשת בחירת יו"ר הכנסת מעיבות על כניסת ברק

חמי שלו

ממשלת ברק יוצאת לדרך

הנשיא עזר ויצמן:

"אני ישבתי בממשלת גולדה עם 24 שרים וזה לא כאב לי ולא לאך אחד. הבעיה היא זה לא הגודל אלא ביצוע המשימות"

קווי היסוד של הממשלה החדשה

ביטחון: ● הממשלה מתחייבת לפעול להוצאת זה"ל מלבנון – אך לא מצידון בתוך כמה זמן

התהליך המדיני: ● "ממשלת ישראל תפ־על לשים קץ לסכסוך הישראלי־ערבי בדרכי שלום, מתוך עמידה על בטחונה הלאומי של ישראל"

● "הממשלה תילחם מלחמת חורמה בטרור אך תע־שה לזירוז המו"מ עם הפלשתינאים על בסיס התהליך הקיים, לשם סיום הסכסוך בהסדר קבע, שיובא לאישור במשאל עם"

● גם הסכם השלום עם סוריה יובא למשאל עם. שלום זה יושתת על החלטות 242 ו־338 של האו"ם

ההתנחלויות: ● עד לקביעת מעמדם של הית־שובים ביש"ע במסגרת הסדר הקבע, לא יוקמו התנחל־יות חדשות ולא יפגעו התנחלויות קיימות

חינוך: ● הממשלה מתחייבת לפעול בהדרגה לה־ארכת יום הלימודים בבתי הספר, להפחתה מודרגת של שכר הלימוד במוסדות להשכלה גבוהה ולמתן הלוואות לסטודנטים – בכפוף למגבלות התקציב

קליטה: ● הממשלה מתחייבת להבטיח שכל ע־לה "מהגיל הרך ועד לשיבה טובה" יוכל ללמוד עברית

● ישראל בעליה רשמה לעצמה הישג נוסף כשקיב־לה את ראשות ועדת החינוך של הכנסת

איכות סביבה: ● הממשלה מתחייבת לפעול למניעת זיהום המים והאוויר ולצמצם מפגעים אקולוגי־ים וקרינה גרעינית

תחבורה: ● הממשלה מתחייבת לדאוג לקווי רכבת מהירה ולדאוג ל"קיצור זמני הנסיעה"

קואליציה: ● אין התחייבות מפורשת להגריל את מספר השרים בממשלה אלא מציין שניתן יהיה לע־שות זאת "אם וכאשר ראש הממשלה יגיש הצעה כזו מטעמו"

● ראש הממשלה "רשאי" להכניס תיקון לחוק יסוד הממשלה ולהפעיל את החוק הנורווגי

תכנון: ● ראש הממשלה מתחייב להביא לדיון תוכנית לרפורמה במבנה הממשלה

אריה בנדר

השרים

עם ההרחבה הצפוייה של הממשלה יתווספו עוד 6 שרים:

● מתן וילנאי (ישראל אחת) שר התרבות, המדע והספורט

● חיים (ג'ומס) אורון (מרצ) שר חקלאות

אהוד ברק (ישראל אחת)

ראש הממשלה, שר הביטחון ושר החקלאות

"קיבלנו מנדט ב-17 במאי להוביל את המדינה כולה לאחדות ושינוי וממשלה בראשותי אכן תבצע זאת. קיבלנו מנדט להוביל לביטחון ושלום. אני אומר לכם - אין בעיני מרכזית יותר מאשר המשימה לחזק את ביטחון מדינת ישראל על־ידי השמת קץ לסיכסוך בין 100 השנה במזרח התיכון. אנחנו נשנה את סדר היום הלאומי, נחדש את הצמיחה במשק, נשתלב בכלכלה העולמית. אני מתחייב לעמוד בכל ההבטחות שניתנו גם אם יש כאלה שאינן ניראות כישימות בעתיד

לשאלה, כיצד פרופסור להיסטוריה יוכל להתמודד עם התפקיד, ענה בדעמי:

"אלכסי דה־טוקוויל, בן המאה ה־19, יצר את הספר החשוב ביותר על הדמוקרטיה באמריקה, ותראה לאן הוא הגיע".

רית ירושלים לטובת כל התושבים, ערבים ויהודים על כל גווניהם". מקור ביו של ברק מידרו לות הרבות שיוטלו עליו מרגע כניסתו של ברק לתפקידו כראש ממשלה.

צילומים: ברקאי וולפסון ונאור רהב

גיבורי היום

פרס רוצה סמכויות

מאת רון לוין

ריגע לפני עלייתם של שרי תנועת העבודה לבמה באולם הטירמה, המתיים "משבר פרס", שנמשך 24 שעות בלבד. המשבר נע סביב השאלה, מה יהיו סמכויותיו של ח"כ שמעון פרס כשר לפיתוח אזורי.

בשיחה הראשונה עם אהוד ברק, שנערכה ביום ראשון, העלה שמעון פרס הצעות שונות שאת כולן דחה ברק על הסף, או כפי שהגדירו זאת מקורבים לשניים: "אם זה תלוי בברק, הוא בחלט ימנה את פרס לשר לפיתוח אזורי בלי שום סמכות".

■ איום בהיעדרות

אולם ח"כ פרס, שאין שווה לו במעמדו בעולם ובקשריו הטובים, חזר והדגיש שכל מה שמעניין אותו הוא קידום תהליך השלום. פרס הבהיר לברק, כי מה הכי חשובה לו אפשרות הפעולה בנושאים אלה במסגרת תפקידו החדש, וזה הרבר היחיד שמטריד אותו.

על רקע זה קוימה שיחה נוספת בין השניים, לאחר שפרס הבהיר כי לא מן הנמנע שנוכחותו על הבימה בסינרמה מוטלת בספק. ראש הממשלה הנבנע זימן אותו לפגישה שעסקה במבנה המשרד העתידי ואפשרויות הפעולה למען קידום תהליך השלום.

ח"כ שמעון פרס

בשיחה השנייה בין השניים הוסכם, כי פרס מאשר את מינויו לשר בממשלת ברק, וכי ועדת מנכ"לים בהשתתפות נציגו של פרס תקבע את גודלו, היקפו והסמכויות שיועניקו למשרד הפיתוח האזורי.

כבל הנראה, נציגו של פרס בוועדה יהיה אבי גיל, ראש לשכתו בעבר.

ברעם: עצבות וסימפטיה

מאת רון לוין ובן כספית

אהוד ברק ניסה לחסל את הקריירה הפוליטית של עוזי ברעם ולגמד את זה של שלמה בן־עמי.

זה, בכל אופן, מה שטוענים מקורביהם של השניים. לברעם אמר ברק, בשיחה האישית הקשה שקיימו: "אתה בחור מוכשר, עוזי, אני לא אומר שלא. אבל אין לי מקום הולם עבורך בממשלה. מצד שני, יש עוד הרבה הזדמנויות ותפקידים. בשירות החוץ, למשל. יש שגרירויות חשובות שמתפנות. תוכל לשנות אווירה, לספוג תרבות חדשה".

ח"כ עוזי ברעם, שלא ידע אם לצחוק או לבכות, חזר לעומתו של ברק חיוך מר: "לא רק שאתה משאיר אותי מחוץ לממשלה, אתה גם רוצה להעיף אותי מהפוליטיקה? לא, אני חושב שיש לי עוד כמה דברים להגיד כאן".

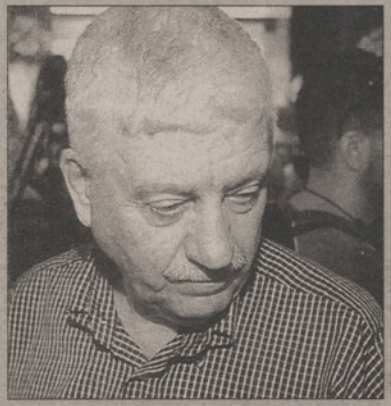
את הפופולריות של עוזי ברעם ניתן היה למדוד אתמול בכנס המרכז של ישראל אחת בסנרמה בתל־אביב. תור ארוך התייצב מולו לחבקו ולהגיד מילה טובה.

"אני לא יכול להבין איך ברק הצליח להרחיק מעליו את ברעם", סח אחד מחברי המרכז.

"הוא מקצוען מהשורה הראשונה, בעל כישורים, בעל ניסיון. ברק שכח כיצד גישש באפלה בתחילת דרכו, והיה זה עוזי ברעם שהלך איתו צעד אחרי צעד. האם כך הוא גומל לו?".

"אני אוהב אותך", אמר לברעם ח"כ שלמה בן־עמי. רגע לאחר מכן ישב ברעם בשורה השנייה, כשאת הראשונה ממלאים זה אחר זה כל מי שנבחרו להיות שרים בממשלתו של ברק.

ברעם, מלווה בבנו ניר, לחץ ידיים וסירב לומר מילת ביקורת על ברק.



ח"כ עוזי ברעם

החוצה. וגם היום, כשאמרתי לשים פתק לבן בקלפי [illegible] הבחירות, בתניהו לברק, אמרו לי: 'לא נדבר איתך'".

בתחום הכלכלי יש לו דעות עוד יותר נחרצות. הוא טוען שהעולם מתפרק מהדמוקרטיה, לטובת שלטון העשירים. "בשנות השמונים החלה מהפכה של העשירים שתפסו את השלטון, באמצעות תאגידים חוצי יבשות, שהם דיקטטורות

שבתאי. "למה זה שלילי שאני מושפע? אפשר להגיד שבדיוק להפך לבנות" ● צילום: מיכה קירשנר

פשיסטיות שיש להן אבטחה ונשק וכוח עצום. כל הכוח של המדינות עובר לתאגידים. מפריטים הכל: את האדמות, אפילו את בתי הסוהר.

"הגלובליזציה הרסה את כל ההגנות על העניים והפועלים בכל העולם. יש שוק עבודה כללי ואנחנו צריכים להרוויח כמו בסין. בעתיד הלא רחוק אנשים בישראל יעבדו 12 שעות ביום כדי להביא לחם הביתה. אני לא רואה איך הילדים שלי יגיעו לדירה, דבר שהיה מובן מאליו בדור שלי. ידענו שנעבוד ונגיע לדירה. היום צריך ששניים יעבדו כדי לפרנס משפחה, בעוד שלפני 20 שנה הספיקה עבודה של אחד. הפוליטיקאים משרתים את העשירים. גם ברק עושה פוליטיקה לעשירים בלבד. חייבים לעשות מהפכה שכנגד שתחזיר לנו את האמון בעצמנו. זה מתחיל לקרות בעולם. תראי מה קרה בסיאטל בזמן ועידת ארגוני הסחר הבינלאומיים".

דעות מרתקות, ועם זאת מבדרות. למה מבבחבחב

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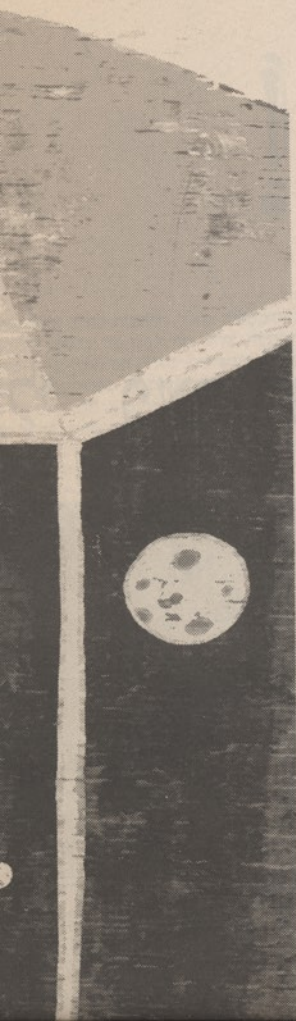


יוסטון, יש לנו ארף בעיות!

נותרו רק עוד עשרים שנה עד להמראת החללית

המאוישת הראשונה למאדים, ובפרק־הזמן הקצרצר הזה מדעני נאס"א מתמודדים עם מספר עצום של בעיות. לא, הם לא דואגים שהקרבורטור יקרוס. הם צריכים לפתור את הבעיות הרפואיות, שמציב מסע בן שלוש שנים לחלל, למשל דיכאון, למשל העובדה שפציעה פשוטה למדיי ברגל עלולה לחייב כריתת הגפיים (ונחשו מה קורה כשנפצעים בראש), למשל העובדה שכל האסטרונאוטים שיישלחו למאדים יחזרו, כנראה, עקרים

ג'רום גרופמן, "ניו יורקר"

איורים: רותו

עוד עשרים שנה, בשנת 2020, מתעתרת סוכנות החלל האמריקאית (נאס"א) לשגר אסטרונאוטים למשימה בת שלוש שנים למאדים (כולל שישה חודשי מסע בכל כיוון). הטכנולוגיה אינה מראיגה את טכנאי נאס"א ומדעניה. יש עוד מה לשפר, נשאר עוד מה לחקור, אבל עקרונית המפתחות בפנים. דווקא הצד הרפואי של המסע למאדים הוא הבעיה. האם בני־אדם יוכלו לשרוד חשיפה ארוכת־טווח לתנאי הקרינה והעדר כוח המשיכה של החלל החיצון? האם ניתן יהיה לטפל במצבי חירום רפואיים של אסטרונאוטים תוך מסעם לחלל? ומה באשר להשפעות הפסיכולוגיות של הלחץ והשהייה בחלל סגור לאורך זמן? אלה הן השאלות החמות בנאס"א כיום.

ולא רק כיום. כבר לפני ארבע שנים הבינו בנאס"א שאין להם מומחים הרוצים להתמחות עם האתגרים הרפואיים שבחקר החלל. הלקית, נכבע הכשל הזה ממורכבות התהליכים, שעובר הגוף האנושי בתנאי החלל החיצון. סיבה מרכזית יותר היא העובדה, שמדעי החיים תמיד היו משניים בסולם העדיפויות של סוכנות החלל, שהציבה תמיד בראש מעייניה את הפיזיקה ואת ההנדסה: בשנה שעברה הוקצו למחקר רפואי פחות משני אחוזים מתקציבה השנתי של נאס"א.

הסוכנות הכירה במגבלה הזו והחליטה להפנות את העבודה המחקרית אל מחוצה לה, לתאגיד המורכב מ־12 מעבדות אוניברי־

אלף בעיות!

(המשך מעמוד קודם)

סיטאיות. התאגיד נקרא 'המכון הלאומי לחקר בירי־רפואי של החלל' (NSBRI), ומטהו ממוקם בבית־הספר לרפואה של בי״ר לור בעיר יוסטון, טקסס. ד״ר ג'ון צ'רלס הוא המדען האחראי למה שמכנה הסוכנות 'מפת הדרך הקריטית' – כלומר פיתוח מחקר רפואי וטכנולוגיה שיהיו חיוניים למסע למאדים ומֵעֵבר לו. הוא אינו ממעיט בערכם של הקשיים הצפויים. "הצלחנו לעבור את הטיסות הקודמות לחלל בזכות הביטחון המופרז שלנו והרבה מזל", הוא אומר, "וגם משום שהאסטרונאוטים ששלחנו לשם היו בכושר ובריאות מעולים".

בשנת 1997 ברקו צוותים מנאס״א ומ־NSBRI את מצבאי משימותיהם בחלל של 279 הגברים והנשים, ששהתפו במס־עות כאלה בין השנים 1988-1995. הם גילו כי כל האסטרונאוטים, למעט שלושה, סבלו במהלך המסעות לחלל ממחלה כלשהי. כן זוהו 175 סכנות רפואיות הקיימות במהלך הטיסה לח־לל. ארבע מהסכנות קיבלו דירוג של רמה 1, שמציין את חומרתן הרבה ואת העובדה שלא ניתן יהיה למנוע אותן או לטפל בהן בזמן אמת.

"כל אחד מאלה יכול להרוס את הח־גיגה", מזהיר צ'רלס, אך מודה ש"המסע למאדים בלתי נמנע. אם אר־צות־הברית לא תעשה זאת ראשונה, אחרים יעשו זאת, אולי הסינים". הוא לא שכח לציין כי קיימת רשימה ארוכה של אסטרונאוטים, שכבר התנדבו למ־שימה. "האנשים הללו הם חוקרים. וכ־מו אצל כל חוקר, מעולם לא הובטח להם כרטיס חזור".

ריר באלפ להקיא!

לצעירים יש הכושר הגופני הטוב ביותר, אלא שהקרינה הקוסמית עלולה להפוך אותם לעקרים. המבוגרים מביאים אתם ניסיון רב יותר, ולפניהם פחות שנות חיים, שבהן הם עלולים לפתח סרטן. אבל הם חלשים יותר

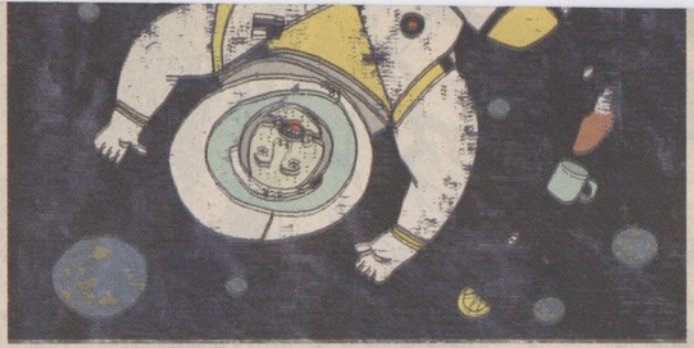
הנובעות מהמסעות בחלל, וסוכנות החלל אינה ששה מצדה לפרסם עובדות אלה. כדי להגן על כבודם של האסטרונ־אוטים השבים ממשימות בחלל, הם מובלים אל מחוץ לחל־לית באמצעות תאים ממונעים על מסלול מכוסה, כך שהעו־לם לא יוכל לראות אותם ממוטטים. אנדרו תומס, אסטרונ־אוט ששהה 141 ימים בתחנת 'מיר' ב־1998, מתאר את התחו־שות שאנו לא רואים (ומן הסתם, גם לא מרגישים):

"נָחַתי במצב של שכיבה וניסיתי להושיט יד אל המצלמה שלי. התחושה הייתה של כובד נוראי, כאילו אני נושא משקו־לת פלדה". מיד עם הנחיתה לקה תומס באובדן התמצאות. כאשר אנשי צוות הקרקע עזרו לו להתרומם על רגליו, הוא הוכה על־ידי כוח המשיכה. "זה היה מדהים", הוא אומר, "עצם הנחת הרגליים על הקרקע בזו אחר זו דר־שה ממני מאמץ אדיר".

הוא התקשה לשמור על שיווי־משקל, וגופו נטה קדימה והתנועע לצדדים. לקח לו שבועות אחדים ללמוד לשמור על שיו־וי־משקל: "וכשניסיתי ללכת בעיניים עצומות", הוא משחזר, "עריין נטיתי לצד־דים ונכנסתי לתוך קירות".

כיצד יצליחו אסטרונאוטים מותשים, ששהו חצי שנה בחלל החיצון, להסתגל למ־אדים, שם עוצמתו של כוח המשיכה היא מחצית מזו של כדור־הארץ וכפולה מזו שהתמדדו אתה האסטרונאוטים של חלל־יות 'אפולו' על הירח? "הבעיה האמיתית תהיה ההסתגלות לפני מאדים, שם לא מח־כה תכנית שיקום מיוחדת לאסטרונאוטים", מציין תומס. "אם נידרש לנקוט פעולת חי־רום, לנטוש במהלך נחיתה או לחמוק דרך פתח המילוט, יש חשש לאסון".

רוקר טוב, ניכנס



חלק מהסכנות הרפואיות שמזמן המסע הארוך מכולם, נובעות מחיים בסביבה נטולת כוח משיכה. "למעשה", אומר צ'רלס, "אתה לוקח אנשים בריאים ומציב אותם בסביבה חולה – בח־לל". המין האנושי התפתח במשך מיל־יוני שנים תחת השפעת כוח המשיכה. הנוזלים והעצם הוזירה שבתוך האוזן הפנימית, שמרכיבים את המערכת השולטת בשיווי־המשקל, תלויים בכוח המשיכה. בהעדר משיכה כזו הגוף אינו יכול לקלוט את האותות הנחוצים לאי־זון ולאוריינטציה.

הבעיות הרפואיות הראשונות מת־עוררות כבר עם ההמראה. אפילו האסט־רונאוטים המתורגלים מרבים להקיא בג־לל הבחילה ואובדן ההתמצאות. לאוזן הפנימית יידרשו מספר ימים כדי להתרגל לתנאים החדשים. במהלך ימי ההסתגלות נר־שלים האסטרונאוטים תרופות נגד בחילות ונעים בתנועות ארר־כות ואיטיות: אפילו השינוי הקל ביותר בתנוחת הגוף, כמו סיבוב חד של הראש, עלול לגרום בחילה.

הבחילות האלה אינן עניין של מה בכך. ראשית, כמעט בכל מסע לחלל מאבד אסטרונאוט כלשהו את שקית ההקאה דווקא ברגע קריטי, ובהעדר כוח משיכה, יוצא הקיא שלו לט־יול ברחבי החללית כולה. או אז נאלצים האסטרונאוטים לא־סוף את הסחורה חלקיק אחר חלקיק באמצעות ספוגית. ואם להתייחס לבעיות קריטיות יותר – גם כשהסחרחורת מתפר־גגת, חלק מהאסטרונאוטים מתקשים לאתר את מיקום ידיהם ורגליהם, מה שלא מומלץ כשמנוטים בחלל.

העדר כוח משיכה גורם שינויים גם במערכת כלי הדם. בדרך־כלל דם מצטבר ברגליים ובחזה התחתון; ואילו בחלל הדם משתחרר ומתרכז דווקא במעלה הגוף. התחושה היא כאילו הולמים בראשך בפטיש. הלב מאיץ את פעילותו כדי להתמודד עם מה שהוא מפרש כעודפי דם, מערכות אחרות בגוף מפרשות את ההרגשה כעודף נוזלים. בתוך יומיים מאבד הגוף שלושה ליטרים מים. התוצאה: התייבשות ודם סמיך יר־תר. סמיכות הדם מאותתת לגוף להפסיק לייצר כדוריות דם אדומות, מה שעלול להוביל לאנמיה.

בבית, כלומר על הכוכב שלנו, נשמרת מערכת השרירים וה־עצמות בזכות התנגדותה התמידית לכוח המשיכה, תהליך בי־לוגי הנקרא עיצוב מחדש. בחלל נטול כוח המשיכה, קצב התה־ליך הזה מואט, ואדם מאבד בממוצע אחוז עד אחוז וחצי של צפיפות העצם בחודש אחד; גם הגידים והמיתרים המחברים בין העצמות נשחקים. כיוון שאין כל התנגדות לתנועה, וכל העצמים נטולי משקל, השרירים מתנוונים: זה מצב שווה־ערך למנוחה כללית במצב מאוזן, כשהגוף עסוק בנגסם.

קיים סרטון של קרוב ל־30 שנה לסדרת עצמות במהלך משימה בת שלוש שנים למאדים. אפילו מתיחות קלות ביותר עלולות לגרום לשרירים ולגידים להיקרע כמו נייר־טואלט. אנשי צוות תחנת החלל 'מיר' ניסו למנוע תהליך זה באמצעות תרגילי התעמלות יומיים, אולם ללא הצלחה רבה.

מלח-מים, מלח-מים

לא רק הדרך חשם מסוכנת. הדרים גבוהים יותר בדרך חזרה: לאחר הסתגלות הגוף למצב של העדר משקל, החזרה לכדור־הארץ ולכפיפות כוח המשיכה מסוכנת מאוד. ב־1989 תיאר האסטרונאוט מאנלי קרטר את השיבה במעבורת חלל לכדור־הארץ כאחת החוויות המתישות ביותר בחייו, ולראשונה החלה נאס"א להתייחס ברצינות לגבולות שהביולוגיה האנושית יכולה להציב למסעות בחלל. אלא שגם כיום עיקר הציוד שמספקת הסוכנות לאסטרונאוטים כדי להתמודד עם השיבה לאטמוספרה, אינו יעיל במיוחד. אלה הן חליפות ג'י עם כיסים מתנפחים, שמפעילים לחץ על הרגליים והאגן כדי לשמור על יציבות לחץ הדם של האסטרונאוט, ותכנית מסודרת של נטילת טבליות מלח ומים לפיצוי על אובדן הנוזלים.

אסטרונאוטים אינם מרבים לדבר על הבעיות הרפואיות שברים בשתי שרשרות הדי־אן־איי, והגוף טרם פיתח מנגנוני שיקום עצמיים שיוכלו להתגבר על המצב".

במעבדות ברוקהייבן בלונג־איילנד נמצא מאיץ־חלקיקים מיוחד שעובר הליך שדרוג, כך שיוכל לחקות קרניים קוסמ־יות על־ידי האצת חלקיקי ברזל. תרביות תאים וכן עכברים וחולדות ייחשפו לקרניים הללו, וכך ייערכו ניסויים שיבדקו את רמות ההשפעה של הקרניים. הראיות הקיימות אינן מעו־דדות: חוקרים כבר ניסו לחשוף עכברים לחלקיקי הברזל עתירי האנרגיה, ומצאו כי החשיפה גורמת שינויים משמעות־יים במוח, המובילים קודם כול לאדישות ולהיחלשות הזיכ־רון. ניתוחים שלאחר המוות הראו שמוחות המכרסמים נתמ־לאו בפצעים ועידים כתוצאה מהקרינה.

הקרניים הקוסמיות גם עלולות לגרום מוטציות מסוכנות של הבקטריות והפטריות שגדלות בעור, בפה ובמעיים, ושל אלה המצויות בחללית. קרינה כזו עלולה להפוך בקטריות רגי־לות לקטלניות ולעמידות בפני אנטיביוטיקה. כמרכז סכנת ההידבקות במחלות גדלה, כיוון שהמערכת החיסונית סובלת אף היא מליקויים מסוימים בחלל. אסטרונאוטים שנשלחו למשימות הדמיה בבידוד גמור באנטארקטיקה, סבלו מכשלים בתאי ה־T, והיו מקרים בהם נרשמה גם התעוררות של וירוסים רדומים.

באופן בלתי מפתיע מתברר שחשיפה לקרניים קוסמיות מגבילה את הסיכויים לחלות בסרטן. בדיקות שנערכו באסט־רונאוטים, כמו אלה ששהו בתחנת החלל 'מיר' וטסו במסלול סביב כדור־הארץ, מלמדות שמספר השברים בכרומוזומים

אבל מהם האסונות הקטנים הללו לעו־מת הסיכון שבקרניים הקוסמיות? אלה קר־ניים המורכבות בעיקרן מחלקיקי ברזל, שנעים במהירות הקרובה למהירות האור. הן יכולות לחדור עמוק אל תוך הגוף, אפי־לו דרך הגולגולת. כשהחלקיקים המואצים חודרים דרך הרקמות, הם מעוררים תגובה גרעינית. נחמד, לא?

"על־פני כדור־הארץ אנו סובלים משב־רירים קטנים בשרשרת אחת של הדי־אן־איי מקרני אולטרה־סגול וקרני x", מסביר ד"ר פרנסיס קוצ'ינוטה, מנהל פרויקט הק־רינה בחלל של נאס"א. בחלל הפגיעה צפ־ויה להיות חמורה בהרבה. "בהתחשב בעוצ־מת האנרגיה הגבוהות של קרניים קוסמ־יות", ממשיך קוצ'ינוטה, "נוצרת סדרה של

...ו זאת שוב ● ה„פת'פיינדר" נחת על הכוכב ביום שישי, 7:57 בערב שעון ישראל

תעודת זהות

קוטר המאדים: כמחצית מקוטר כדור־הארץ.
מסה: כעשירית מכדור־הארץ.
טמפרטורה: בין מינוס 143 מעלות עד 25 מעלות (פלוס) צלסיוס.
אקלים: לעתים סופות חול עזות, שמהירותן עולה על 100 קמ"ש.
לחץ אטמוספרי: קטן מאוד – 7 אלפיות האסטמופירה (לעומת אטמוספירה אחת על כדור־הארץ).
חמצן: כמעט אין. רוב האטמוספירה מורכבת מפחמן דו־חמצני.
מים: יש מים קפואים בקטבים, אבל רוב הכוכב צחיח לחלוטין.
פני הקרקע: דומים לכדור־הארץ. הצבע האדום נובע מריכוז גבוה של תחמוצות בריזל. הנוף נקבע על־ידי פגיעת מטאוריטים, פעילות געשית וסופות חול.
מרחק מכדור־הארץ: כאשר כדור־הארץ ומאדים מתקרבים זה לזה, המרחק מצטמצם לכדי 80 מיליון ק"מ.
אורך היממה: דומה לשלנו – 24 שעות, 50 דקות ו־30 שניות.

עמוס כרמל

כך נחת רכב החלל
על המאדים -
ראה עמודים 12־13

כך נראה המאדים. שבעה חודשים נסע ה„פת'פיינדר" עד שהגיע אליו

תגובות היום

אימה ברחובות

קרן הרחובות לוינסקי

ראש
החלל ה

„הישג
ערל מ