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Progress Report  
14 December 1992

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P-40

Solar System Exploration Division  
National Aeronautics and Space Administration  
Washington, DC 20546

## Teaching, Learning, & Planetary Exploration

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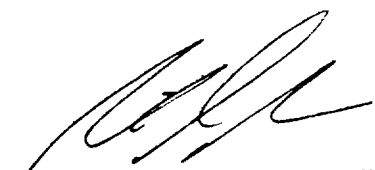
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Inst.) 40 p

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Robert A. Brown  
Principal Investigator

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## Progress Report

This report presents the progress accomplished in the first five months of the three-year grant period of *Teaching, Learning, and Planetary Exploration* (NAGW-3048).

The objectives of this project are to discover new education products and services based on space science, particularly planetary exploration. *An Exploration in Education* is the umbrella name for our education projects as they are seen by teachers and the interested public. As described in our proposal—and in our numerous writings—our approach consists of: (1) Increasing practical understanding of the potential role and capabilities of the research community to contribute to basic education using new discoveries. (2) Developing an intellectual framework for these contributions by supplying criteria and templates for the teacher's stories. (3) Attracting astronomers, engineers, and technical staff to the project and help them form productive education partnerships for the future. (4) Exploring relevant technologies and networks for authoring and communicating the teacher's stories. (5) Enlisting the participation of potential user's of the teacher's stories in defining the products. (6) *Actually producing and delivering many educationally useful teacher's stories.* (7) Reporting the pilot study results with critical evaluation.

As described and illustrated below, (1) We have made technical progress by (1a) assembling our electronic publishing stations; (1b) designing electronic publications based on space science; (1c) developing distribution approaches for electronic products; (2) We have made progress addressing critical issues by (2a) developing policies and procedures for securing intellectual property rights; (2b) assembling a focus group of teachers to test our ideas and assure the quality of our products; (3) We are actually producing some useful materials, including (3a) the TOPS report; (3b) three electronic "PictureBooks"; (3c) one "ElectronicArticle"; (3d) three "ElectronicReports" in progress, (3e) ten "PrinterPosters", (3f) the "FaxForum" with an initial complement of printed materials; and (4) We have coordinated with planetary scientists and astronomers both at the technical and policy level to

Assure the efficiency and ultimate utility of these efforts to derive educational benefits from the space science and exploration program as a whole.

## 1. TECHNICAL PROGRESS

Electronic publishing is important for educational products based on space science and exploration because the immediacy of electronic products can capture the excitement of discovery, such products are modular and can be incorporated into larger learning units, and the incremental cost per copy is negligible. Further, electronic products take advantage of the rapidly increasing installed base of suitable equipment—computers and fax machines—in schools and homes. A major thrust of our program is to master electronic publishing for the purposes of education based on the space science and exploration programs.

### 1.A ELECTRONIC PUBLISHING STATION

During the current reporting period, we have strengthened our computer setup, and we now have a significant multi-media authoring capability. We are able to capture sounds, video, still images (from data files, slides, and hard-copy), and text, and we are able to assemble these materials into educational products in the form of software, printed copy, and on-demand fax documents. Some of the products in section 3 illustrate the existing capabilities. We are now expanding the input modes to include still-frame and video camera (for people-based material), and the output modes to include video tape and cd-rom.

### 1.B ELECTRONIC PUBLICATION DESIGN

We have designed three electronic products based on space science and exploration: "PictureBooks", "ElectronicArticles", and "ElectronicReports". Our design activity consisted of determining the functional requirements on these products, designing their appearance and feel, writing the appropriate software or computer structure, and developing the methods and procedures to go from the basis material to the finished electronic product. Our accomplishments are illustrated by the examples discussed in section 3.

In general terms, our design emphasizes exploration by the student in original materials based on research. For example, the student is

presented images returned by the *Magellan* spacecraft to browse, and where interest strikes, to pursue to deeper levels, first to a glossary of technical words and beyond that to tutorials and exercises teaching fundamental concepts. Such user-driven exploration is well suited to "hyper" computing, and we have selected the Macintosh based HyperCard application as our initial platform. In the near future, we will have cross-platform products.

### 1.C DISTRIBUTION APPROACHES

Our initial distribution mode has been floppy disk, but we have made significant progress towards other less costly distribution modes for our electronic products. We are now activating a computer bulletin board that can be called by teachers in our focus group to download our products. We have made our initial products available to commercial on-line services for distribution to the public. We are exploring cd-rom authoring as a way to collect and distribute electronic publications in bulk. We have discussed possible commercial distribution approaches with the Discovery Channel and the Apple Computer Corp. (Of course, no compensation to the grant-related parties is envisioned.)

## 2. CRITICAL ISSUES

This grant supports a research project rather than an operational mission in education. Our emphasis is on discovering frameworks, methods, procedures, etc. that we believe are elements in overall educational solutions. Our ultimate role is to share and communicate our results and experiences in the expectations that our successes will inspire serious follow-on programs, and that our errors will not need to be repeated. In this spirit, we are addressing a variety of issues that bear on research-based education generally. In the current reporting period we worked on two issues: intellectual property rights and teacher feedback.

### 2.A INTELLECTUAL PROPERTY RIGHTS

The basic material for educational products based on space program results consists of images and ideas created by others. When this material is incorporated into the new educational products, the right to do so must be secured.

We can distinguish three cases: NASA-generated materials (no problem), contractor-generated non-copyrighted materials (rights must be secured from owner or contracting officer, as appropriate), and original copyrighted material (rights must be secured from owner according to owner's conditions).

Our efforts have focussed on establishing definite procedures at ST ScI to determine and secure permission for the rights to use basic materials with each of these origins. We are now testing these procedures on particular cases falling into each of the three property rights categories.

## 2. B QUALITY ASSURANCE

We have asked a small group of interested teachers to interact with us and provide us feedback on the utility of our products. The current focus group consists of:

Thomas A. Allen	Teacher	Auburn Academy	Auburn, WA
L. Blanchard Byrne	Teacher	Elmme/Beimond Junior High	Klemme, IA
W Ward Lester	Teacher	Martin County High School	Steward, FL
Edith B. Merritt	Teacher	Vernel Elementary School	Tuscaloosa, AL
Richard Smith	Dept. Chair	Cabrillo Middle School	Ventura, CA
Jim Zimmerman	Teacher	Thomas Paine School	Urbana, IL
Holly Huitgren	Principal	Nederland Elementary School	Nederland, CO
Jane Moberg	Teacher	George Fox Middle School	Pasadena, MD
Fred Donelson	Teacher	Gahanna Lincoln High School	Gahanna, OH
James G. Hill	Obs. Director	French Camp Academy	French Camp, MS
M. Colleen Kozumpak	Dept. Chair	Loretto High School	Sacramento, CA
Ralph T. Pillsbury	Teacher	Port St. Lucie High School	Port St. Lucie, FL
Sandra L. Lester	Teacher	Dan McCarty Middle School	Fort Pierce, FL
Bonnie L. Bracey	Teacher	Ashlawn Elementary School	Arlington, VA
Karen Cowan	Teacher	Mendenhall Middle School	Livermore, CA
Rick Farrar	Teacher	Northern High School	Accident, MD

## 3. PRODUCTS

During the reporting period we have produced a variety of materials that are either supportive or illustrative of our educational objectives.

### 3. A THE TOPS REPORT

This widely-admired report of the TOPS science working group describes a NASA plan to discover and study other planetary systems.

Figure 1 is the cover of the TOPS report. This is a subject with established public appeal, and one objective of the *Exploration in Education* program is to assure the educational benefits of the TOPS program. Indeed, the TOPS report itself recommends

coupling of the TOPS Program with education and the public. In the last 30 years, NASA's planetary program, through its dramatic visits to the planets of our solar system, has forged a process that has transformed the excitement of modern-day exploration. Its success has been due in large part to the solidity and resilience of the program's framework. The astronomers and planetary scientists writing this report wish to continue this tradition of excellence by maximizing the public's opportunity to participate in the search for planets around other stars. Our search for other planets is, after all, a Nation's quest. The great public curiosity about the existence of extrasolar planets should thus be encouraged by the TOPS research program. Whereas *Mariner*, *Pioneer*, and *Voyager* returned a deluge of magnificent pictures, the special nature of the TOPS investigations will benefit from a concerted educational program to enhance the public's understanding of the research and its results.

We have begun the TOPS educational program with the report itself, which we plan to distribute soon as an ElectronicBook.

### 3.B ELECTRONIC PICTUREBOOKS

We have invented the PictureBook as the electronic equivalent of a slide set with tutorial and captions, of which there are many wonderful sets based on space science and exploration. We have produced three thus far: *Magellan at Venus*, *HST's Greatest Hits*, and *Terrestrial Impact Craters*. We have many others now in process. Figures 2-7 illustrate the three existing PictureBooks.

### 3.C ELECTRONIC ARTICLES

We have chosen this name for electronic publications based on small written articles illustrated by figures and possibly video or audio clips. We have used a design different from the PictureBook design to

better accommodate the dominance of text over graphics. We have produced one electronic article based on the spin-cast 6.5 meter mirror recently made at the University of Arizona. This Electronic Article, blurred in Figure 8, includes a desktop video clip of the melting mirror glass.

### 3.D ELECTRONIC REPORTS

We are well underway with three electronic books, which will have design features similar to the Electronic Articles. The three Electronic Report in progress are *TOPS, A Strategy for Recovery, and Spaceguard Survey*. The blurbs are Figures 9-11.

### 3.E PRINTER POSTERS

We have created a concept for posters based on mosaics of normal letter-sized paper. Students can readily assemble these posters for the walls of their classrooms or their homes. The benefits of this sort of poster: easy copying (Xerox), possible electronic distribution (fax machine), and simple reproduction and distribution as hardcopy (gummed pad).

We have created 10 such posters, which are illustrated in Figure 12-22 at 1/4-1/3 normal size.

### 3.F FAXFORUM

We have activated an on-demand fax-based distribution system for documentation both about and for *An Exploration in Education*. The benefit of this mode of communication is that interested parties can call in on their schedule with a touch-tone phone and request document (including indexes of documents), which are then transmitted to their fax machine.

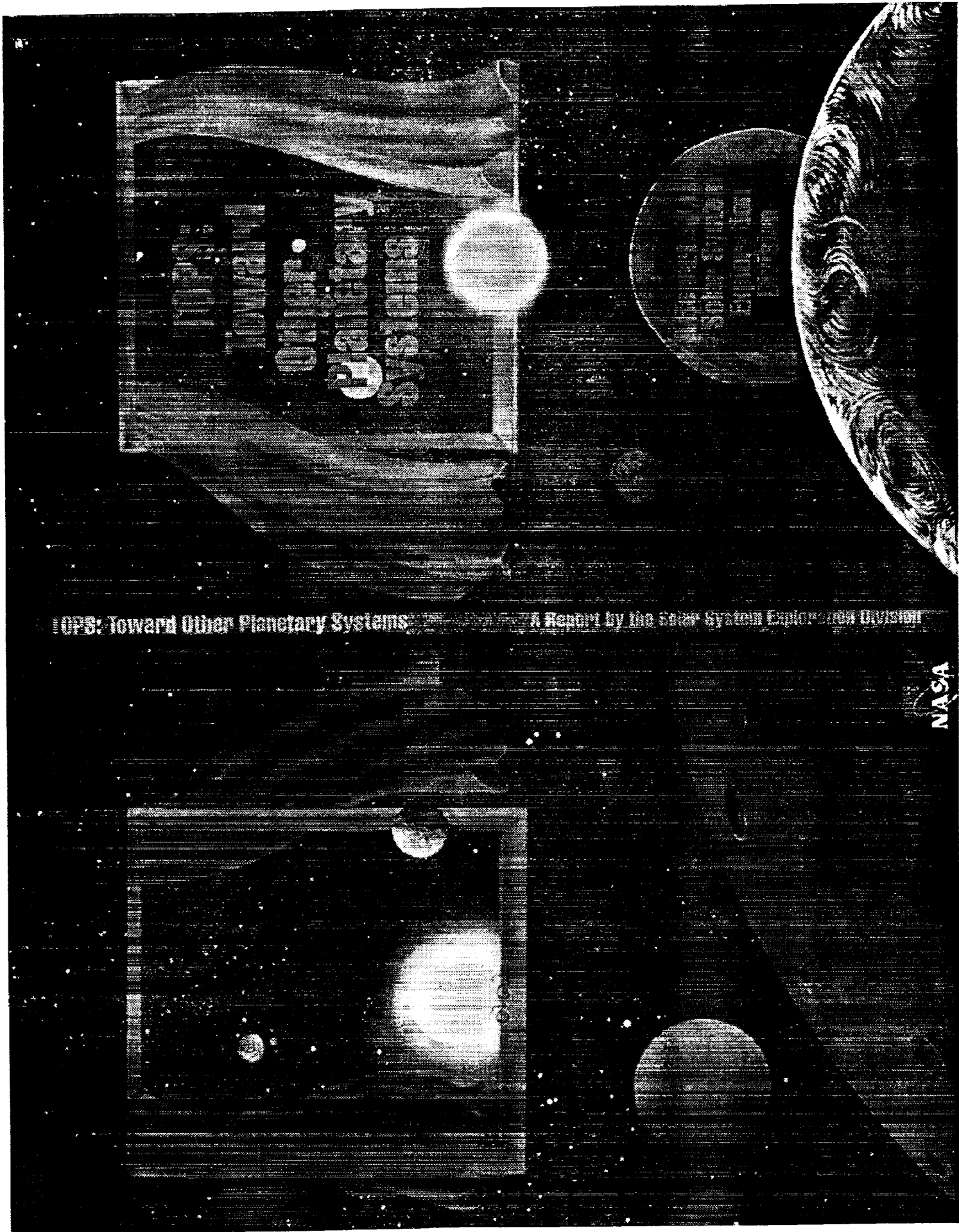
Figure 23 shows the current contents of FaxForum related to education.

## 4. COMMUNITY COORDINATION

A very important aspect of our work is communicating an orientation toward education to our scientific colleagues, and developing channels through which they can participate and develop the educational potential of their own work. To this end, we have attended—

usually by invitation—several meeting to describe and discuss the objectives of *An Exploration in Education*, including: Solar System Exploration Subcommittee (Washington; La Jolla), Astronomical Society of the Pacific (Madison, WI; San Francisco), Division for Planetary Sciences (Munich). At these meetings, in both formal presentations and informal discussion, we have made important contacts regarding both the directions of our research and ideas for future educational content and concepts.





OPS: Toward Other Planetary Systems A Report by the Solar System Exploration Division

NASA

ORIGINAL PAGE IS OF POOR QUALITY

Figure 1

# Magellan at Venus



Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

Click anywhere to continue.

### Index

Click a name in the numbered list to go straight to that picture.

- 1. Through Features
- 2. Wind Streaks
- 3. Gridlike Plains
- 4. Nova and Loma Patera
- 5. Western Capla Fretta
- 6. Soviet Venus (Belagol 8)
- 7. "Pancake" Volcanic Dome
- 8. Impact Crater Aurelia
- 9. Ridge Belts in Lavinia
- 10. Saccapetra Patera Volcano
- 11. Dunes in Eryx Montes
- 12. Lid Jost Plains
- 13. Craters in Regas 1 Crater
- 14. Maxwell Montes
- 15. Lora-Robbed Crater
- 16. Seabon Volcanic Channel
- 17. Dark Hill Impact Crater
- 18. Volcano Si Mono
- 19. Abysses of Impact Craters
- 20. Duna Montes

### Tutorial

Magellan is a NASA spacecraft mission to map the surface of Venus with imaging radar. The basic scientific instrument is a synthetic aperture radar, or SAR, which can look through the thick clouds perpetually shrouding the surface of Venus.

Magellan is in orbit around Venus which completes one turn around its axis in 243 Earth days. This period of time, one Venus rotation, is the length of Magellan's primary mission. During that time Magellan will map about 80% of the Venus surface. Subsequent missions of equal duration will provide complete mapping of the planet. Magellan was launched May 4, 1989, aboard the Space Shuttle Atlantis and went into orbit around Venus August 10, 1990. The spacecraft completes one orbit every 3 hours and 19 minutes, passing as close to the planet as 294 km and as far away from Venus as 8,072 km. The smallest visible objects measure approximately 120 meters.



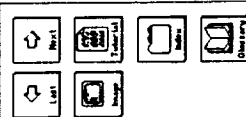
7. "Pancake" Volcanic Dome  
7 of 20

**7. "Pancake" Volcanic Dome**  
25 km diameter, 20.5, 11.2 E  
November 7, 1990

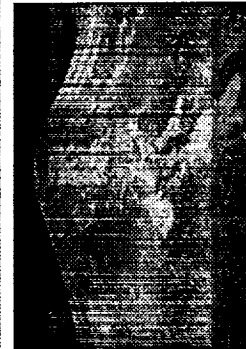
This image of the eastern edge of Alpha Regio was acquired in November 7, 1990. It shows seven circular domical hills averaging 25 km in diameter with maximum heights of 750 meters. These features can be interpreted viscous or thick eruptions of lava coming from a vent on the relatively level ground allowing the lava to flow in an even lateral pattern. The concentric and radial fracture patterns on their surface suggest if they are extrusive that is called outer layer formed, then further intrusion in the interior stretched the surface. The dome may be analogous to volcanic dome on Earth. An alternative interpretation is that domes are the result of



10. Saccapetra Patera Volcano  
10 of 20



18. Volcano Si Mono  
18 of 20



20. Duna Montes  
20 of 20

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Figure 2

## *Magellan at Venus*

Magellan, a NASA spacecraft sent to map the surface of Venus with imaging radar, was launched May 4, 1989 aboard the space shuttle Atlantis, and began radar operations for its mapping mission at Venus on September 15, 1990. The basic scientific instrument used on Magellan was a synthetic aperture radar, or SAR, able to look through the perpetually thick clouds of Venus to the planet's surface, which prior to Magellan had been virtually "unseeable" in any detail. Magellan made surface objects as small as 120 meters (400 ft) visible, thus providing valuable new insight into the geological history of the planet.

The "Magellan at Venus" PictureBook, created from an existing slide set distributed by the Jet Propulsion Laboratory in Pasadena, California, contains a selection of 20 of some of the most intriguing images and image mosaics of the surface of Venus, including views of mountains and plains, volcanoes and impact craters. The captions accompanying the pictures provide information about these surface features, including their location in latitude and longitude, a general description, and "guesses" as to what the features might represent in geological terms. The text also provides information about the images themselves, including the date the image was acquired, and the image resolution.

The PictureBook is built on a Hypercard stack and is designed to run on a Macintosh computer with HyperCard 2.1 and QuickTime 1.5.


This PictureBook is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the producers directly, the Electronic Picturebooks are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

For more information on the ExInEd program, or to provide comments or suggestions on the Electronic Picturebook concept, please write: Dr. Robert A. Brown, Special Studies Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, or FAX your comments to (410) 516-7450.

For more information about the Magellan project, please write: Public Information Office, Jet Propulsion Laboratory, California Institute of Technology, National Aeronautics and Space Administration, Pasadena, California 91109, or call (818) 354-5011.

Figure 3

# HST Greatest Hits




Pre-Release Version, November 17, 1992.

Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218

Click anywhere to continue.


HST Greatest Hits

1. Saturn  
1 of 25



HST Greatest Hits

8. Supernova Ring 1987A  
8 of 25




HST Greatest Hits

1. Saturn  
1 of 25

This color image of Saturn was taken with the HST's Wide Field and Planetary Camera (WFPC) in the wide field mode at 8:25 A.M. EDT, August 26, 1990, when the planet was at a distance of 1.36 billion km from Earth.

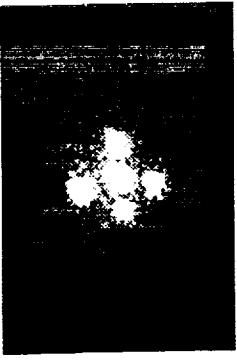
The color in the image was reconstructed by combining three different pictures, taken in blue, green and red light (4900, 5470 and 7180 Angstroms).

Image reconstruction techniques have been applied to yield greater spatial detail in the planet's ring system and cloud belts than can be achieved with ground-based telescopes. Image resolution is 500 km per picture element (pixel). Saturn appears much as one would see it if it were only twice as far away as the Moon.



HST Greatest Hits

10. Einstein Cross  
10 of 25



HST Greatest Hits

Click a name in the numbered list to go straight to that picture index.

1. Saturn
2. Storm on Saturn
3. Pluto & Charon Double Planet
4. Orion Star-forming Region
5. E. Kuiper Symplectic Star
6. Irua Cold Spiral
7. Mars, 3 Color Channels
8. Supernova Ring 1987A
9. Eta Carinae
10. Eastern Cross
11. Gamma Cassiopeiae Outbur
12. M15 Globular Cluster
13. M11 Globular Cluster
14. Ring Planet Spectrum
15. M87 Jet
16. NGC 1275
17. Gravitational Lens
18. M107 Alpha Forest
19. M107
20. Helix 1166 in LMC
21. M89 250
22. M51 "X" Jet's Tail
23. M33 Ring Galaxy
24. Cepheid Variable Stars
25. NGC 4261

HST Greatest Hits

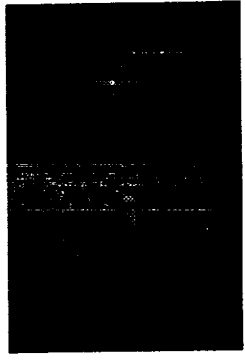
Tutorial

1 of 9

When Lyman Spitzer first proposed a giant, earth-orbiting telescope in 1946, the nuclear energy sources of stars had been known for just a few years. Knowledge of galaxies beyond our own and the understanding that our universe is expanding were only about twenty years of age in the human consciousness. The planet Pluto was seventeen. Quasars, black holes, gravitational lenses, and detection of the Big Bang were still in the future—together with much of what constitutes our current understanding of the solar system and the cosmos beyond it. In 1990, forty-four years after it was first conceived, the earth-orbiting Hubble Space Telescope (HST) became a reality...

HST Greatest Hits

15. M87 Jet  
15 of 25



HST Greatest Hits

25. NGC 4261  
25 of 25




Figure 4

## *HST's Greatest Hits*

The Edwin P. Hubble Space Telescope (HST) was launched and deployed in low Earth orbit (368 miles or 593 kilometers above the Earth) on April 24, 1990. A 94 1/2 inch (2.4 meter) reflecting telescope, the HST is designed to remain in operation in space for 15 years. It is the largest, most complex, and most sensitive civilian space observatory deployed by the U.S. National Aeronautics and Space Administration (NASA), and is in the process of undertaking, jointly with the European Space Agency (ESA), an international program of scientific exploration of the cosmos.

The "HST's Greatest Hits" PictureBook presents some of the most spectacular and informative images taken with the scientific instruments of the HST during its first year of operation. Created from an existing slide set distributed by the Space Telescope Science Institute in Baltimore, Maryland, the PictureBook contains a selection of 24 images and highlights new theories about phenomena such as gravitational lenses and black holes now being developed as a result of these HST images. The captions accompanying the pictures provide information about the visual data contained in the individual images, including a general description of the features shown, and interpretations by the research astronomers involved. The text also provides information about the images themselves, including the date the image was acquired, and the image resolution. The PictureBook also contains a glossary of terms.

The PictureBook is built on a Hypercard stack and is designed to run on a Macintosh computer with Hypercard 2.1 and QuickTime 1.5.

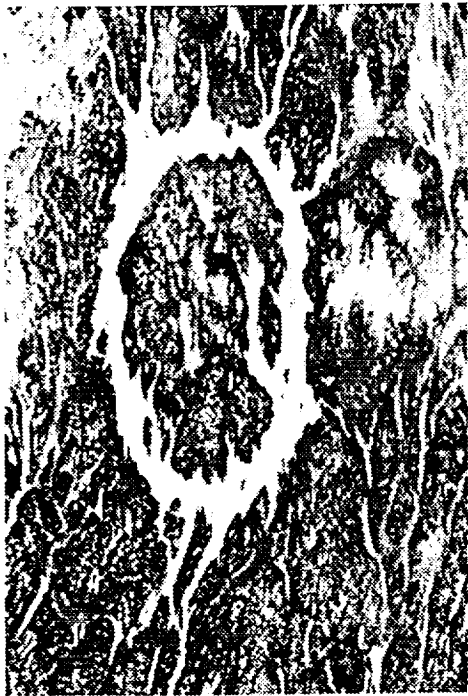
This PictureBook is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the producers directly, the Electronic Picturebooks are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

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For more information about the Hubble Space Telescope, please write: Educational and Public Affairs Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218 or call (410) 338-4562.

Figure 5

# Terrestrial Impact Craters



Pre-Release Verston, November 23, 1992  
Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058

Click anywhere to begin.

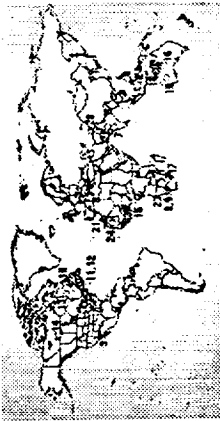
## Tutorial

Impact craters are geologic structures formed when a large **asteroid (extraterrestrial or comet)** smashes into a planet or satellite. All the inner bodies in our solar system have been heavily **bombarded by meteoroids** throughout their history. The surfaces of the Moon, Mars, and Mercury, where other geologic processes stopped millions of years ago, record this bombardment clearly. On the Earth, however, which has been even more heavily impacted than the Moon, craters are continually erased by erosion and redeposition as well as by volcanic resurfacing and tectonic activity. Thus only about 150 terrestrial impact craters have been recognized, the majority in geologically stable regions of North America, Europe, and Australia, where most exploration has taken place. **Spacecraft orbital imagery** has helped to identify structures in more remote locations for further investigation.

Meteor Crater (also known as Barringer Crater), Arizona, was

## Location Map

Click on a crater location to go straight to a map of that region. On the regional map, click on a crater location to go straight to that image.



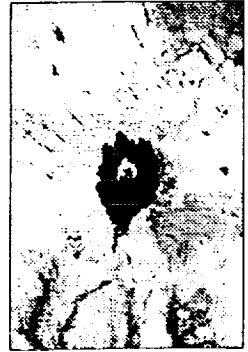
Meteor Crater  
5 of 24

**Meteor Crater, Arizona**  
35°02'N, 111°00'W  
Rim diameter: 1.2 km  
Age: 25,000 years

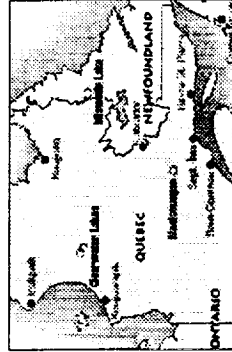
The origin of this classic simple meteorite impact crater was long the subject of controversy. The discovery of fragments of the Canyon Diablo meteorite, including fragments within the **breccia deposits** that partially fill the structure, and a **range of shock metamorphic features** in the target evidence proved the impact origin. Target rocks include **Elsalvador carbonates and sandstones**. These rocks have been overturned just outside the rim during ejection. The hummocky deposits just beyond the rim are remnants of the ejecta blanket. This aerial view shows the **dramatic expansion of**



13. Clearwater Lake  
13 of 24



10. Minnerlin Lake  
10 of 24



Click on a local crater location to turn to a photo  
plate of that crater.



11. Meteor Crater  
11 of 24

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Figure 6

## *Terrestrial Impact Craters*

Impact craters are craters formed when meteorites strike the surface of a planet. They are found on all of the terrestrial planets, on Earth's Moon, and on many of the satellites of the outer planets. Because impact has played a fundamental role in shaping the Earth's surface, studying these craters can help us understand the natural forces that drive our planet's evolution.

The "Terrestrial Impact Craters" PictureBook presents 16 orbital and aerial photographic views of proven or suspected impact structures on Earth. Although there are likely hundreds of impact craters on Earth, they are not easily recognized because of the intense weathering and erosion that continually wear away Earth's surface: mountain building, plate tectonics, weathering and erosion. The pictures selected therefore represent a compromise between those with the best surface expression and those that represent a diversity of age, size and appearance. The PictureBook also contains several examples of impact structures on Earth's planetary neighbors. These relatively well-preserved extraterrestrial craters provide an important reference to understanding the more eroded impact features on Earth.

The "Terrestrial Impact Craters" PictureBook, created from an existing slide set distributed by the Lunar & Planetary Institute in Houston, Texas, contains a selection of 25 images. The captions accompanying the pictures provide information about the individual impact structures, including their location in latitude and longitude, a general description, and explanations of what the features mean in geological terms. Locations of all the 25 structures are provided on maps. A glossary of terms is also included.

The PictureBook is built on a Hypercard stack and is designed to run on a Macintosh computer with HyperCard 2.1 and QuickTime 1.5.

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Figure 7

## *6.5 Meter Mirror Casting*

Science is often driven by technology, and inventing new technology is clearly the business of the Steward Observatory Mirror Laboratory in Tucson, Arizona. Its latest achievement is the successful casting of a 6.5 meter diameter borosilicate honeycomb mirror. Developing the tools and techniques necessary for this achievement have been the goals of a 10-year project aimed at eventually producing affordable, high-quality 8 meter telescope mirrors.

The "6.5 Meter Mirror Casting" Electronic Article, created from a paper written by J.M. Hill and J.R.P. Angel of Steward Observatory describes the process of casting this remarkable 6.5 meter mirror. It includes descriptions and photos of the project from the initial mold building in June 1991 to the final cooling process, which was completed a year later. A large part of the Article deals with the annealing process itself, which involved melting 10 tons of glass in a furnace and rotating it at a speed of 7.4 rpm for 70 hours at a peak temperature of 1180°C to form the desired parabolic mirror surface. This process was captured in time-lapsed photography and is included as a short video in the Article.

The mirror will be used in Steward Observatory's Multiple Mirror Telescope (MMT) conversion project which involves upgrading their existing MMT to a monolithic (single-mirror) 6.5 meter aperture telescope. This Electronic Article captures the inventors' excitement and is instructive of how technological invention can advance scientific discovery. It is a brief but fascinating look at science from a technology perspective.

"6.5 Meter Mirror Casting" is built on a Hypercard stack and is designed to run on a Macintosh computer with Hypercard 2.1 and QuickTime 1.5.

The Electronic Article is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the producers directly, the Electronic Articles are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

For more information on the ExInEd program, or to provide comments or suggestions on the Electronic Article concept, please write: Dr. Robert A. Brown, Special Studies Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, or FAX your comments to (410) 516-7450.

For more information about the Steward Observatory Mirror Laboratory, please write: Steward Observatory, University of Arizona, Tucson, AZ 85721, or FAX your questions to (602) 621-1532.

Figure 8



## *TOPS*

Curiosity about the origin and evolution of planets other than Earth is not limited to those in our solar system. Rather, as technologies improve and capabilities expand, interest in the astronomical community has moved to looking for planets around other stars. With this interest comes the prospect of discovering another or even many planets like Earth—ones that might, in the most exciting of possibilities, harbor intelligent life.

The National Aeronautics and Space Administration (NASA) is in the process of developing a program to explore just such possibilities. Named the "Towards Other Planetary Systems," or TOPS program, it is being established to fulfill two major science goals: to discover and study a significant number of fully formed planet systems and then, as technologies advance, to investigate individual systems and their planets. The program will be implemented in three phases: a ground-based observational phase, a space-based observational phase, and a "new technology" phase, using whatever technologies can be developed to make it possible to observe individual planets and their systems directly.

The "TOPS" Electronic Report has been created from a landmark report of the Science Working Group of NASA's Solar System Exploration Division, which was assigned to develop a plan and to name the technologies needed to implement this program. A fascinating collection of historical information, technical description, and intellectual expectation, the Electronic Report captures the scientific excitement and philosophical tension of discovering and exploring new planets, and the possibility of encountering new forms of life.

The Electronic Report is built on a Hypercard stack and is designed to run on a Macintosh computer with Hypercard 2.1 and QuickTime 1.5.

This Electronic Report is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the producers directly, the Electronic Reports are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

For more information on the ExInEd program, or to provide comments or suggestions on the electronic Electronic Report concept, please write: Dr. Robert A. Brown, Special Studies Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, or FAX your comments to (410) 516-7450.

For more information about the TOPS program, please write: NASA Headquarters, Code SLC, Two Independence Square, 300 E Street, S.W., Washington, D.C. 20546, ATTN: Dr. Jurgen H. Rahe or FAX your questions to that office at: (202) 358-3097.

Figure 9

## *A Strategy for Recovery*

The Hubble Space Telescope (HST) was launched on April 24, 1990. By June 1990, NASA had discovered a problem with the telescope's optics: spherical aberration of the primary mirror. Unsatisfied with a solution of simply redesigning all 2nd generation instruments, which would result in the telescope's capabilities being greatly lessened until the new instruments were put in place in 1997, NASA sought an innovative plan. In August 1990, NASA authorized the Space Telescope Science Institute to convene an HST Strategy Panel to search for additional or alternative solutions. This panel, led by Drs. Robert A. Brown and Holland C. Ford, invented an intriguing solution to the problem of spherical aberration, to be implemented during the first HST servicing mission in December 1993. The "fix," as it was called by the HST Strategy Panel and later adopted by NASA, is a "Corrective Optics Space Telescope Axial Replacement" or COSTAR, an instrument that will place corrective mirrors in front of the openings that admit light into three of HST's observing instruments, refocussing the light before it enters them. COSTAR will restore the optical performance of these instruments to a level sufficient to conduct most of their original science programs. One instrument, the Wide Field and Planetary Camera (WF/PC), cannot be corrected with the COSTAR, so will be completely replaced with a modified version of the instrument.

This Electronic Report, "A Strategy for Recovery," presents the history and plans for HST's recovery with COSTAR. Created from the full-length report of the HST Strategy Panel, it contains the original text and graphics, and includes as well a movie of the COSTAR's planned deployment and a full glossary of terms.

The Electronic Report is built on a Hypercard stack and is designed to run on a Macintosh computer with Hypercard 2.1 and QuickTime 1.5.

This Electronic Report is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the producers directly, the Electronic Reports are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

For more information on the ExInEd program, or to provide comments or suggestions on the Electronic Picturebook concept, please write: Dr. Robert A. Brown, Special Studies Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, or FAX your comments to (410) 516-7450.

For more information about the Hubble Space Telescope or COSTAR, please write: Educational and Public Affairs Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218 or call (410) 338-4562.

Figure 10

## *Spaceguard Survey*

Should the Earth be struck by an asteroid or comet larger than 1 km in diameter, the consequences are potentially catastrophic and, in fact, could totally alter the Earth's climate. What are the risks of such an impact? Probably small, but the truth is, *we really don't know.*

In light of this uncertainty, the National Aeronautics and Space Administration (NASA) is considering a program to search for and analyze the orbits of Earth-crossing asteroids (ECAs), with the idea that the potentially dangerous objects could be destroyed or their orbits changed in time to cause them to "miss" Earth. Named "The Spaceguard Survey," the program would entail a systematic survey of all ECAs by monitoring a large volume of space around Earth and analyzing the orbits of frequently appearing objects, as well as those whose larger orbit makes them visible only every 5-10 years. NASA is considering this 25-year program as an international effort, involving a world-wide network of specialized ground-based telescopes. If the program were to begin now, utilizing smaller projects already in place, and were to expand to full capacity by the end of this century, the risk of a catastrophic impact could be reduced by more than 75% over the next 25 years.

This "Spaceguard Survey" Electronic Report was created from the formal report of the NASA International Near-Earth-Object Detection Workshop and it outlines and explains the plans and rationale for this comprehensive search. A tutorial on asteroids and comets, and a compendium of images, as well as a fascinating description of the proposed program, the Electronic Report is a fun and educational "read" for all ages.

The Electronic Report is built on a Hypercard stack and is designed to run on a Macintosh computer with Hypercard 2.1 and QuickTime 1.5.

This Electronic Report is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the producers directly, the Electronic Reports are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

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For more information about The Spaceguard Survey program, please write:

Figure 11

## *Views of the Solar System*

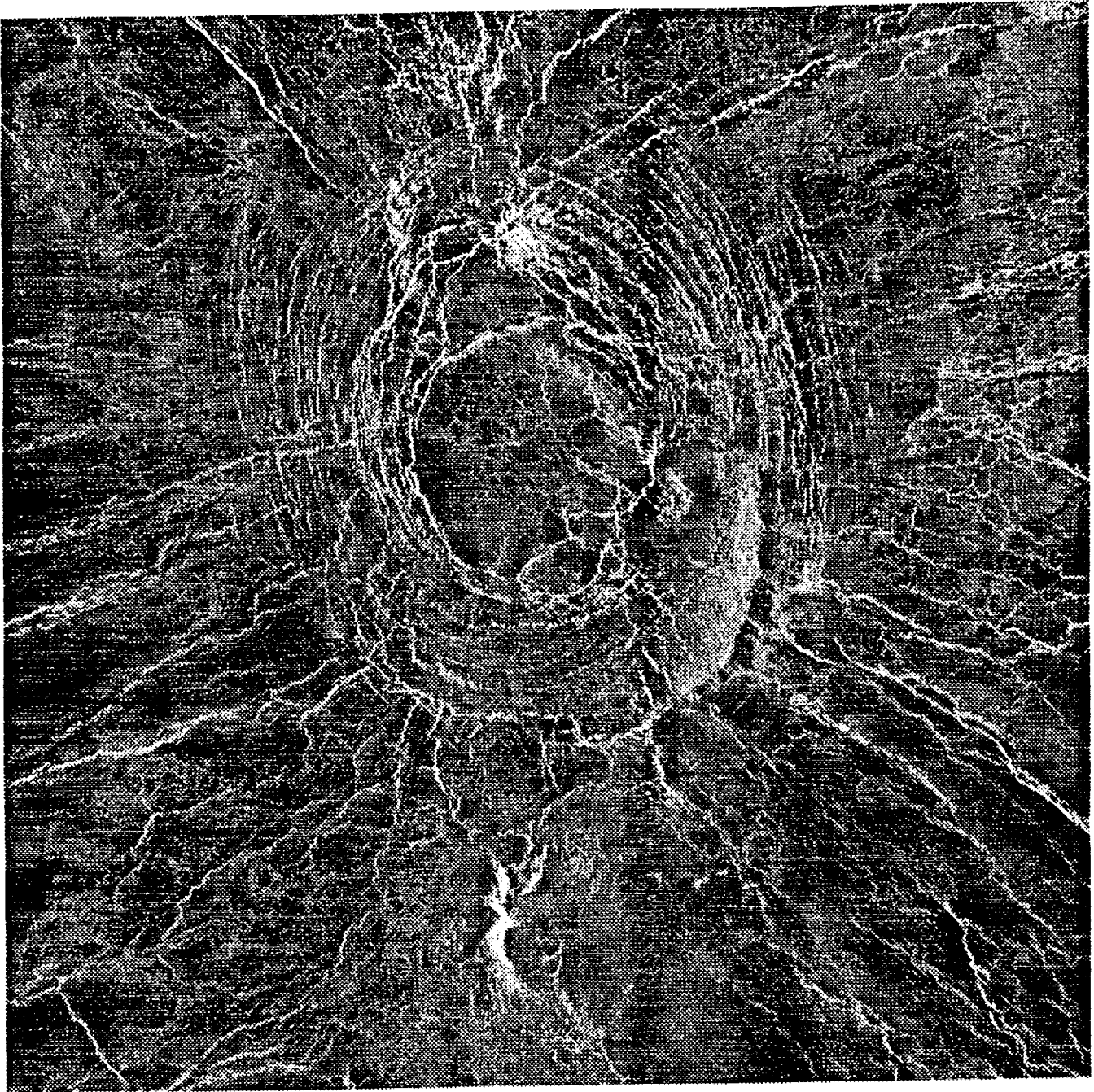
Our knowledge of the Solar System, trapped for ages within the vision-obscuring bounds of Earth's atmosphere, was freed in the 1960s when unmanned spacecraft, complete with cameras, probes, and other data sensors, were launched into space to explore our sister planets. Today, these worlds have become familiar to us and our understanding of their geology and history, though far from complete, is greatly expanded as a result of these journeys into space.

We have collected ten of the extraordinary images obtained by these unmanned machines into a set of PrinterPosters for fun at home and in the classroom. The poster set, available free-of charge in hard copy or on diskette, can be photocopied or printed out on a standard laser printer. Each poster is made up of a number of 8 1/2 x 11 sheets which you can tape or glue together into a wall-sized poster of one of the worlds of our Solar System. The "Views of the Solar System" set includes images of Saturn, Venus, Mars, Jupiter, Mercury, and Earth.

This PrinterPoster set is one of a series being produced by the Exploration in Education (ExInEd) program at the Special Studies Office of the Space Telescope Science Institute. The purpose of the ExInEd program is to discover new tools and approaches to relate space science and exploration to basic teaching and learning, and it involves searching for new ways to assemble and distribute the results of research, particularly images. Currently available by contacting the Special Studies Office directly, the PrinterPosters are eventually intended for distribution worldwide over computer networks from bulletin boards and on-line services, and by inclusion on magnetic or optical disks.

For more information on the ExInEd program or its products, or to provide comments or suggestions on the PrinterPoster concept, please write: Dr. Robert A. Brown, Special Studies Office, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, or FAX your comments to (410) 516-7450.

Figure 12

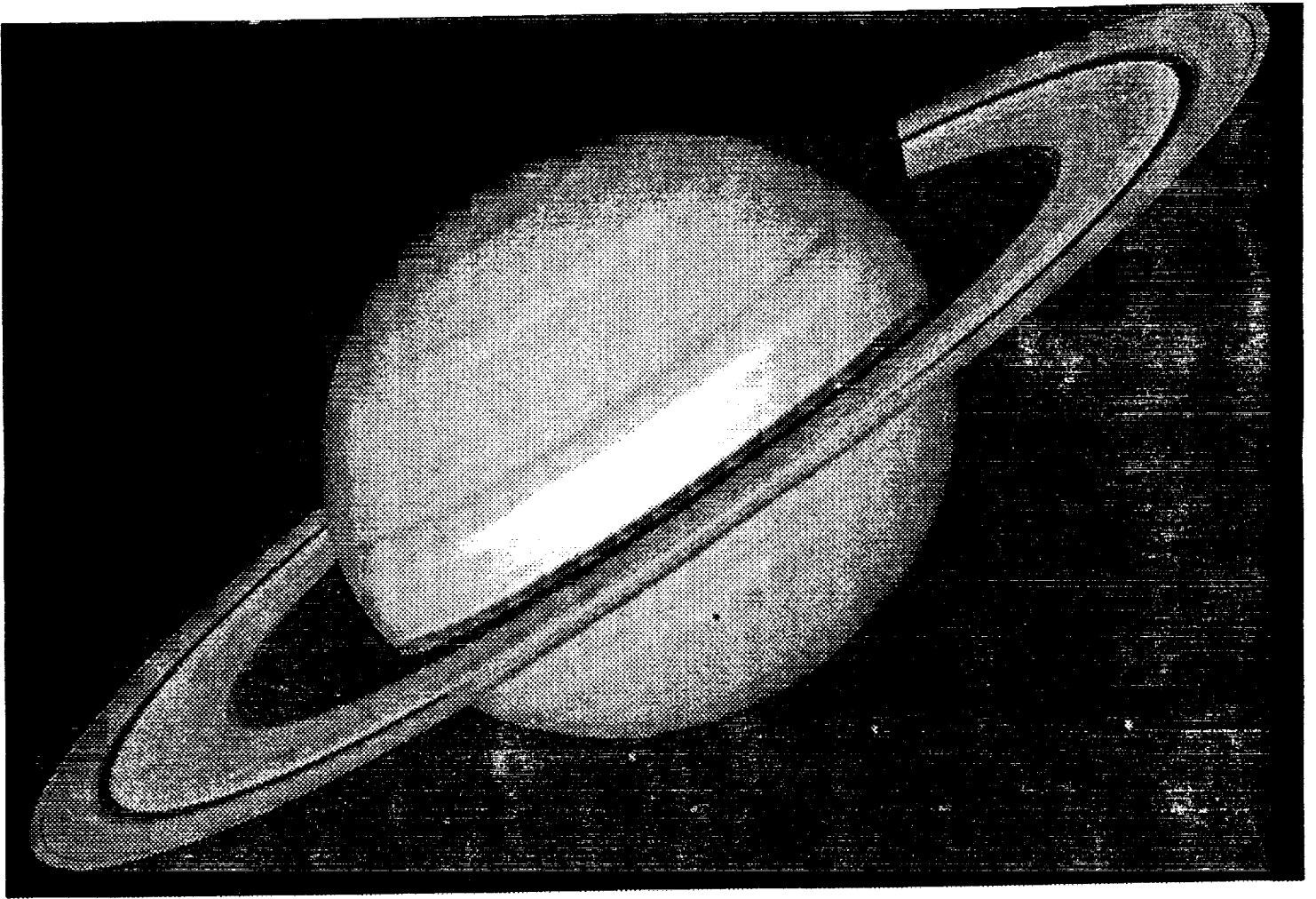


## Venus

Magellan acquired this view of Venus during its first mapping journey around the planet in orbit during 1990 and 1991. This region, roughly 1000 km on a side, shows a gigantic volcanic structure known as a corona. Such features are thought to be the result of hot rising bodies of magma which reach the crust and cause it to partially melt and collapse, generating volcanic flows and fault patterns that radiate from the central structure.

David Byrne, USA, from Mission Venus, 1990, by NASA, Houston, TX, 1991

Figure 13



## Saturn

Voyager acquired this view of Saturn and three of its satellites while approaching the ringed planet. The disk of Saturn casts a shadow across the rings. The satellites Mimas, Enceladus, and Tethys seen in the lower right all orbit Saturn in the plane of its rings and its equator.

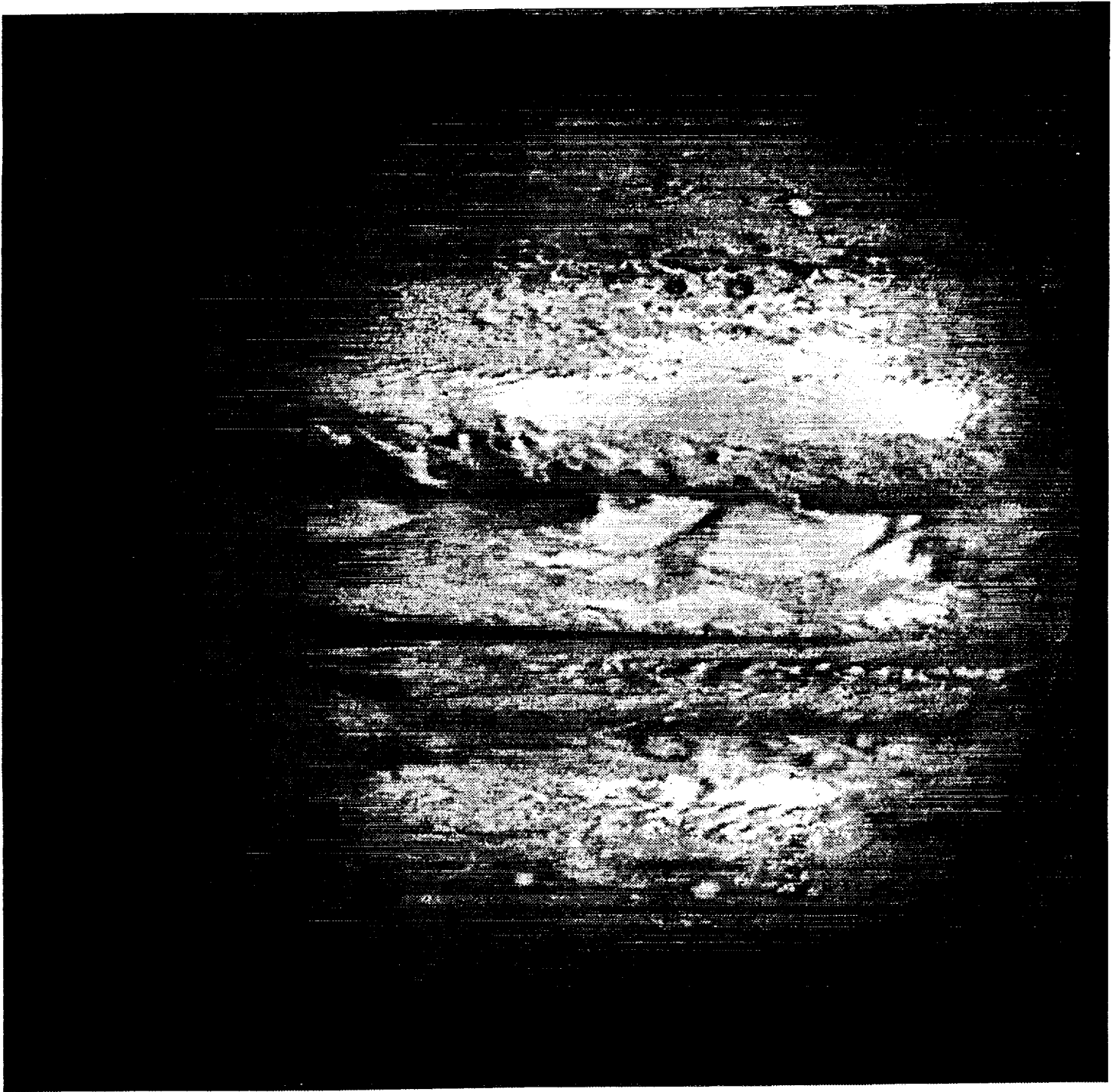




## **Ophir Chasma**

This perspective view of the Ophir Chasma region of Mars was generated by a computer from a combination of Viking Orbiter images and a model of the surface topography. This is part of the enormous Valles Marineris canyon system in the central equatorial region. The region covered is about 200 km on a side. The depth of the canyon is about 6 km.

Figure 15

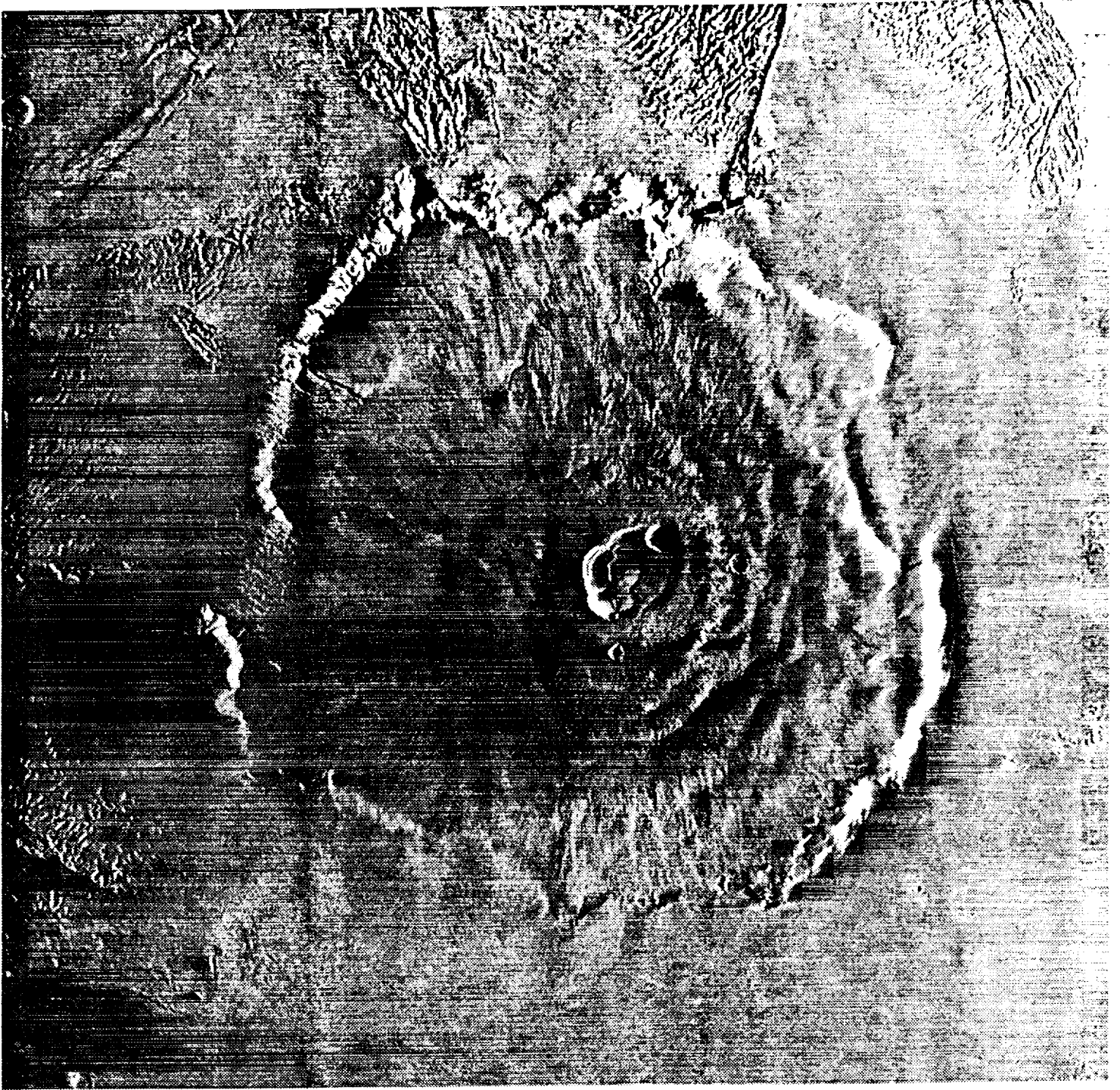


## Jupiter

This Voyager image of Jupiter shows belts (dark) and zones (light) that move relative to one another in east and west directions with velocities of hundreds of meter a second.

Figure 16

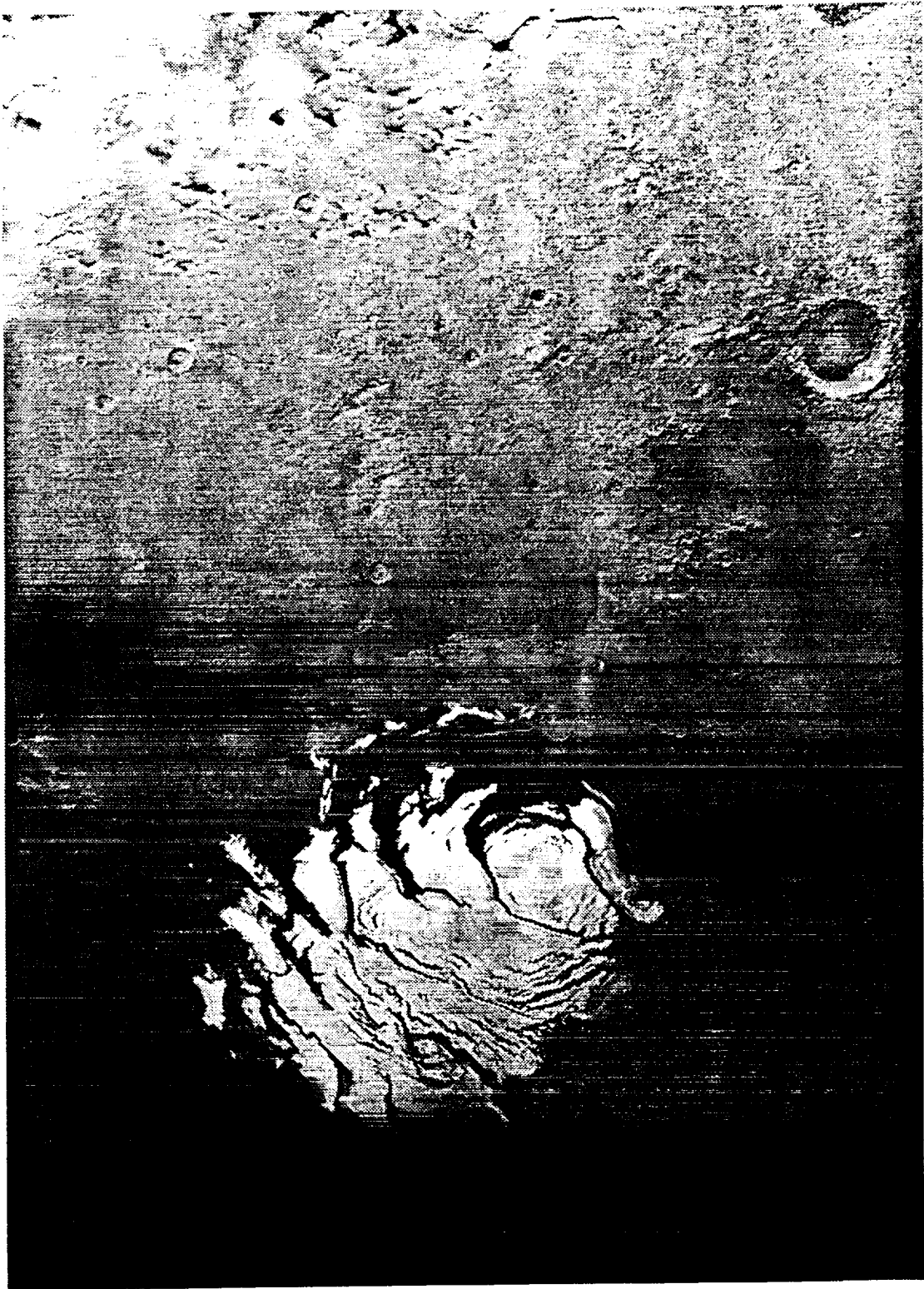




## Mars

Mosaic of Viking Orbiter images of a large volcanic construct in Mars' north equatorial region. Olympus Mons is roughly the width of the state of Arizona at its base. It exceeds the altitude of Mt. Everest by about 10 miles.

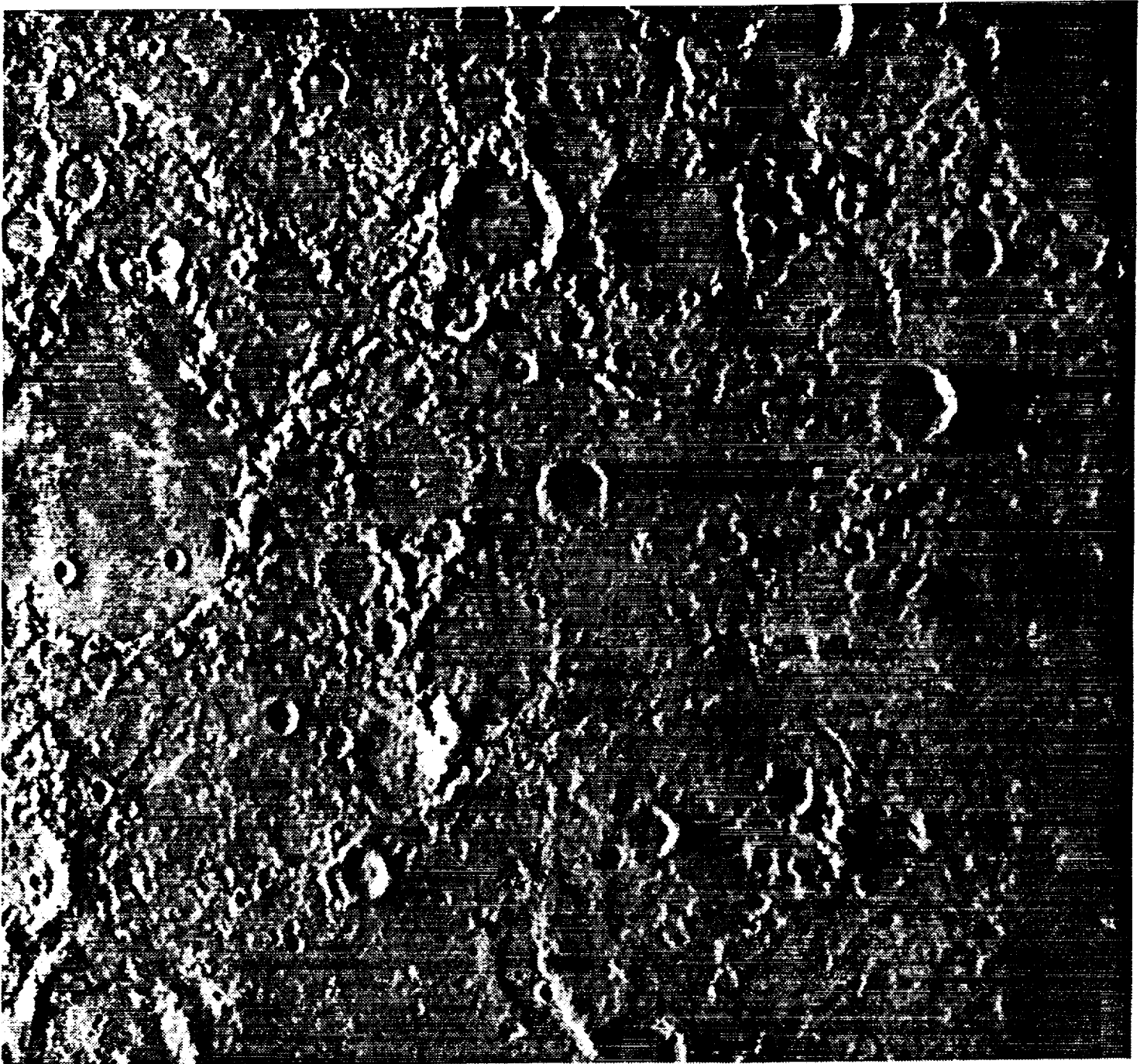
Figure 17



## **Mars' South Pole**

This Viking Orbiter mosaic shows the south polar cap of Mars near its final stages of retreat near the end of southern summer. The temperature of this cap is controlled by carbon dioxide ice keeping it at a temperature near 130 K throughout the martian year. The cap is approximately 500 km in diameter.

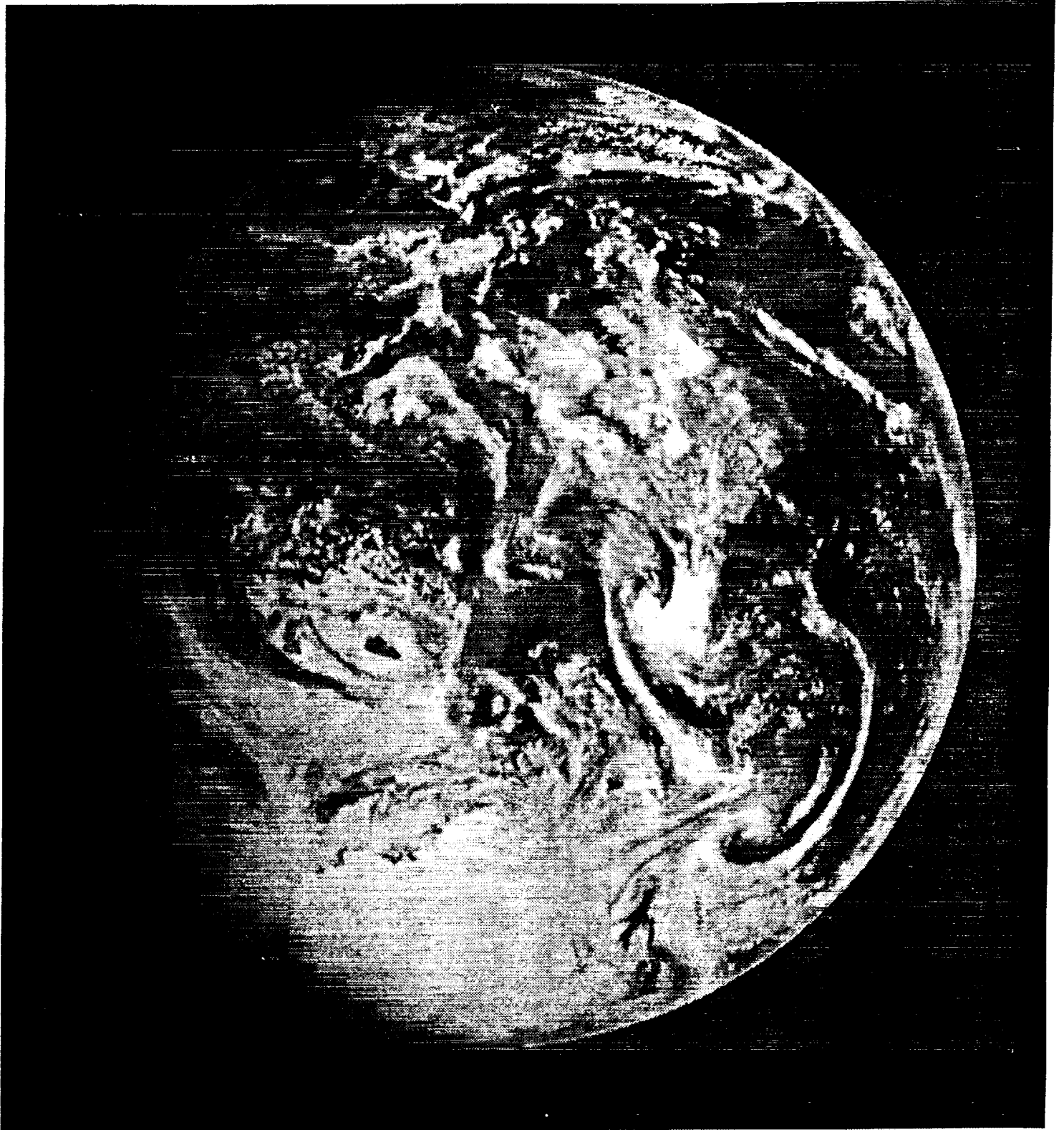
Frame 18



## Mercury

This Mariner 10 image of Mercury shows a region of the planet termed "weird terrain." This region is at the antipodal point to the large Caloris Basin. Perhaps the shock wave of the impact that produced the Caloris Basin was focused in this region, jumbling the crust into a maze of complex blocks. The area shown is about 100 km on a side.

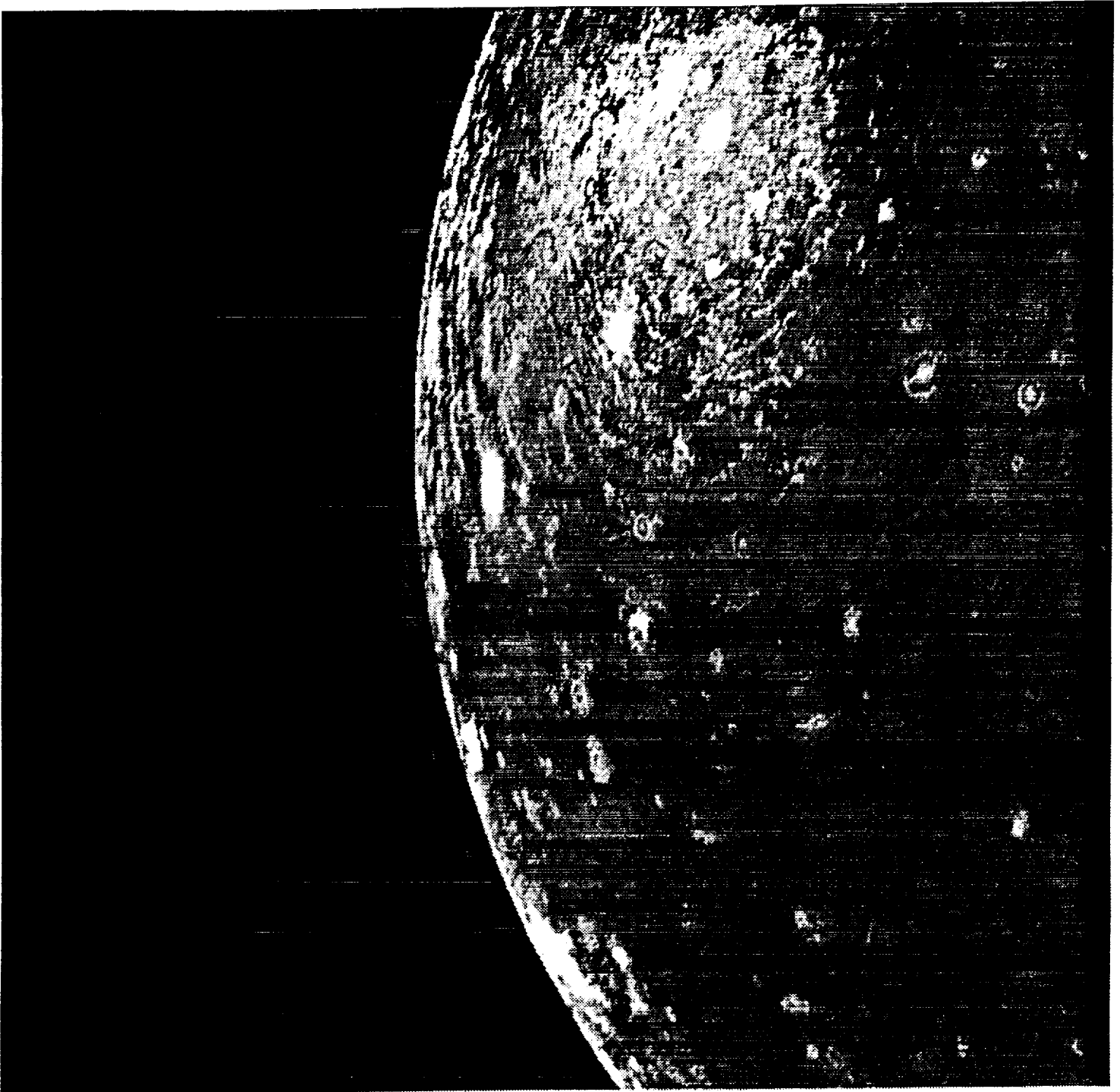
Figure 19



## Earth

Galileo obtained this picture of the Earth on December 11, 1990, when the spacecraft was about 1.3 million miles away. South America is near the center, and the white, sunlit continent of Antarctica is below. Weather fronts are visible in the South Atlantic, lower right.

Figure 20



## Callisto

This Voyager image of Callisto shows a global scale, ancient scar of an impact that occurred when the icy crust was soft and pliable. Enormous rings surrounding the central target zone record the crustal response as the enormous impact cavity collapsed.

Figure 21





## **"Big Joe"**

On July 20th, 1976, the Viking 1 lander provided us with our first close-up views of the martian surface, a scene reminiscent of terrestrial deserts. "Big Joe", the large block in the near-field, is 2 meters across.

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## 3000 An Exploration In Education

0 items/no list

### 3100 Educational Products Workshop

0 items/no list

*We are striving in this section of the FaxForum to highlight new educational products that successfully connect science research with basic education. Our plan is to create and, as appropriate, to collect existing stand-alone elements that eventually can be pulled together into a larger, more complete unites which we will call "teacher's stories." Thus far we have developed two new products, PrinterPosters and Electronic PictureBooks, which we believe do an excellent job of conveying the results of research and which we have found can be distributed quickly by electronic means. We hope you will be encouraged to test out the products below by either distributing them to your students or using them directly in your classroom teaching. Product descriptions and ordering instructions for the electronic publications are available through the FaxForum. Any comments or suggestions you may have about these products are welcome.*

#### 3110 Posters

0 items/no list

#### 3111 PrinterPosters

10 items 9/15/92

## 3111 Solar System Fax Posters

- 001 **Index**
- 301 **Jupiter** This Voyager image of Jupiter shows belts (dark) and zones (light) that move relative to one another in east and west directions with velocities of hundreds of meter a second. 9 pgs
- 302 **Mars** Mosaic of Viking Orbiter images of a large volcanic construct in Mars' north equatorial region. Olympus Mons is roughly the width of the state of Arizona at its base. It exceeds the altitude of Mt. Everest by about 10 miles. 9 pgs
- 303 **Venus** Magellan acquired this view of Venus during its first mapping journey around the planet in orbit during 1990 and 1991. This region, roughly 1000 km on a side, shows a gigantic volcanic structure known as a corona. Such features are thought to be the result of hot rising bodies of magma which reach the crust and cause it to partially melt and collapse, generating volcanic flows and fault patterns that radiate from the central structure. 9 pgs
- 304 **Earth** Galileo obtained this picture of the Earth on December 11, 1990, when the spacecraft was about 1.3 million miles away. South America is near the center, and the white, sunlit continent of Antarctica is below. Weather fronts are visible in the South Atlantic, lower right. 9 pgs
- 305 **Callisto** This Voyager image of Callisto shows a global scale, ancient scar of an impact that occurred when the icy crust was soft and pliable. Enormous rings surrounding the central target zone record the crustal response as the enormous impact cavity collapsed. 9 pgs
- 306 **Saturn** Voyager acquired this view of Saturn and three of its satellites while approaching the ringed planet. The disk of Saturn casts a shadow across the rings. The satellites Mimas, Enceladus, and Tethys seen in the lower right all orbit Saturn in the plane of its rings and its equator. 9 pgs
- 307 **Mercury** This Mariner 10 image of Mercury shows a region of the planet termed "weird terrain." This region is at the antipodal point to the large Caloris Basin. Perhaps the shock wave of the impact that produced the Caloris Basin was focused in this region, jumbling the crust into a maze of complex blocks. The area shown is about 100 km on a side. 9 pgs
- 308 **"Big Joe"** On July 20th, 1976, the Viking 1 lander provided us with our first close-up views of the martian surface, a scene reminiscent of terrestrial deserts. "Big Joe", the large block in the near-field, is 2 meters across. 9 pgs
- 309 **Mars' South Pole** This Viking Orbiter mosaic shows the south polar cap of Mars near its final stages of retreat near the end of southern summer. The temperature of this cap is controlled by carbon dioxide ice keeping it at a temperature near 130 K throughout the martian year. The cap is 9 pgs

Figure 23/1

approximately 500 km in diameter.

- 310 Ophir Chasma This perspective view of the Ophir Chasma region of Mars 9 pgs  
was generated by a computer from a combination of Viking Orbiter images  
and a model of the surface topography. This is part of the enormous Valles  
Marineris canyon system in the central equatorial region. The region covered  
is about 200 km on a side. The depth of the canyon is about 6 km.  
3112 Mail-Order Posters 1 item 12/01/92

### 3120 Electronic Publishing

*Electronic publishing promises to be an increasingly effective method of authoring and distributing educational results of scientific research. The distinctive benefits are (1) negligible recurring cost; (2) efficient dissemination via telecommunications; (3) new ways for users to interact with information. This location describes what we've done and how we've done it. Also, it provides bug reports and comments we have received. We invite anyone interested to download our test products from our bulletin board, 410-516-4880 (to be operational Dec. 1992).*

## **3120 Electronic Publishing**

001 Index

301 Overview of Current Projects

- 3121 Electronic PictureBooks 3 items 12/01/92
- 3122 Electronic Articles 0 items/no list
- 3123 Electronic Reports 0 items/no list

3200 Literary Forums

+ 3210 Interdisciplinary Learning

0 items/no list  
0 items/no list

22 items 10/16/92

3211 America's Valuation of Exploration  
*Americans typically link "exploration" (intellectual, geographic, scientific, etc.) with other inherently positive concepts, such as "freedom" and "opportunity". The documents in this location—which consist mainly of excerpts from articles and essays on the topic of exploration—seek to examine the important influence the concept has had on the shaping of America's history and current perspective. We hope that you will find these selections valuable in a variety of educational settings and subject areas, particularly to spark interdisciplinary discussions and conceptual thinking.*

## **3211 America's Valuation of Exploration**

Americans are unusual in their ongoing tendency to mythologize about exploration and to praise its linkage with the values of freedom and opportunity. The tendency shows up clearly in American language, cultural heroes, laws, and politics.

This section of the FaxForum is set up to engender discussion about the idea and value of exploration. The materials it contains offer information and insight into the American perspective on exploration by touching on its history and future in our society, and its perceived purpose and long-term effect. Documents numbered in the 300s are excerpts from popular writings which have been selected primarily on the basis of how well they convey this perspective. They focus loosely on exploration in science and space, the two investigative trends of perhaps the most urgent interest to Americans today. The first pieces (300-306) comment on the motivations of exploration and the effect these motivations have had on American character and personality. The next four pieces consider how and why the American government has historically taken an interest in and continues to fund exploration (307-310). Ideas on exploration from some recent U.S. presidential leaders are next (311-314), followed by two commentaries on the significance of exploration to education (315-316). The remaining thought pieces (317-321) present several opinions about the future directions, value, and impact of American exploring. We have indicated in this index what we think are appropriate grade levels and subjects for each document and are have included a keyword index (below). We hope that you will find the selections valuable in a variety of educational settings and subject areas, particularly to spark interdisciplinary discussions and conceptual thinking.

This section of the FaxForum also contains information on popular national educational projects developed around the theme of exploration. These documents are numbered beginning with 500. If you know of other proven projects that are concentrated on developing the theme of exploration for educational purposes and are



national in scope, please send us the information and we will post them in this section also.

In fact, any additions, comments, or suggestions you may have regarding any of these selections will be very much appreciated. Please send your thoughts to us via fax at (410) 516-7450 or e-mail to ishee@avion.stsci.edu.

**Keyword Cross-reference** (Numbers in parentheses are document numbers minus 300.)

exploration	0, 3, 8, 9, 10, 11, 12, 14, 17, 19, 20	planet	10, 17	intellect	1
space	0, 11, 12, 16, 18, 19	science	12, 21	mission	14
federal funding	7, 8, 11, 18	Antarctica	20	NASA	10
individualism	1, 5, 6, 7	army	8	observation	2
pioneer	5, 6, 7, 13	benefit	0	opportunity	1
character	4, 5, 6	challenge	16	passion	3
Earth	10, 15, 17	choice	21	perspective	20
knowledge	0, 15, 21	computer	16	prestige	11
spirit	0, 9, 12	democracy	6	purpose	3
astronomy	2, 3	discovery	2	research	18
education	15, 16	economy	9	romanticism	9
freedom	13, 14	engineer	8	society	21
frontier	1, 13	environment	9	technology	5
government	7, 11	evolution	19	telescope	2
intelligence	18, 19	future	15	traits	1
Moon	14, 15	ice	20	unknown	12
nature	3, 4	identity	4	west	8
		innovation	16		

001 *This index*

5 pgs

300 **BECAUSE IT'S THERE.** Some thoughts of Henry Fairlie on why America should be exploring space.

2 pgs

space  
exploration  
spirit  
knowledge  
benefit

From: "Because It's There" by Henry Fairlie. Reprinted from *Roll Call* newspaper, April 17-23, 1989. [British-born writer Henry Fairlie, formerly a contributing editor of the *New Republic*, died in late 1989.]

• 6-8, 9-12. *Science, English, History, Social Studies, Psychology.*

301 **THE AMERICAN MINDSET.** An excerpt from F.J. Turner's seminal essay "The Significance of the Frontier in American History." (1893)

1 pg

frontier  
opportunity  
intellect  
traits  
individualism

From: *The Significance of the Frontier* by Frederick Jackson Turner (New York: Holt, Rinehart and Winston, 1962) pp. 37-38.

• 9-12. *History, Social Studies, Psychology.*

302 **THE WORK OF ASTRONOMERS.** A brief commentary on the hopes and frustrations of the celestial explorer.

1 pg

astronomy  
discovery  
telescope  
observation

From: *Handbook of the Lick Observatory of the University of California* by Edward S. Holden, LL.D. (San Francisco: The Bancroft Company, 1888) pp. 59-60.

• 6-8, 9-12. *Science, Astronomy, History, Psychology*

303 **PASSION OR PRACTICAL PURPOSE?** Simon Newcomb affirms the pure joy of exploring nature through astronomy. (1897)

1 pg

astronomy  
exploration  
passion  
nature  
purpose

From: "Aspects of American Astronomy" by Simon Newcomb in *Astrophysical Journal*, Vol. VI (1897):289-309.

• 9-12. *Science, Astronomy, History, Geography, Psychology*

- |     |   |        |   |
|-----|---|--------|---|
| 304 | <b>A COMPLEX FATE.</b> Historian Perry Miller on the shaping of American character and personality.<br>From: <i>Nature's Nation</i> by Perry Miller (Cambridge: The Belknap Press, 1967) pp. 1-13.<br>• 6-8, 9-12. <i>English, History, Social Studies, Psychology</i>  | 3 pgs  | character<br>identity<br>nature                                   |
| 305 | <b>PIONEER HERO.</b> An analysis of the American public's reaction to Lindbergh's flight across the Atlantic Ocean.<br>From: "The Meaning of Lindbergh's Flight" by John W. Ward in <i>Studies In American Culture</i> , Joseph J. Kwiat & Mary C. Turpie, eds. (Minneapolis: University of Minnesota, 1960) pp. 27-40.<br>• 6-8, 9-12. <i>Science, English, History, Geography, Social Studies, Psychology</i> | 7 pgs  | individualism<br>character<br>pioneer<br>technology               |
| 306 | <b>AMERICAN INDIVIDUALISM.</b> Herbert Hoover says it is the basis of our successful democracy and an aspect of our pioneer spirit.<br>From: "American Individualism" by Herbert Hoover in <i>Essays on Current Themes</i> , C. Alphonso Smith, ed. (Boston: Ginn & Company, 1923), pp. 391-400.<br>• 4-5, 6-8-9-12. <i>History, Social Studies, Psychology.</i>  | 1 pg   | individualism<br>character<br>pioneer<br>democracy                |
| 307 | <b>FRONTIER SETTLEMENT &amp; AMERICAN GOVERNMENT.</b> A note on how the U.S. Government's resources and sponsorship assisted the opening of the Western frontier.<br>From: <i>Wagon Roads West</i> by William Turrentine Jackson (Berkeley: Univ. of California Press, 1952) pp. 319-328.<br>• 9-12. <i>History, Economics, Government, Social Studies.</i>   | 1 pg   | pioneer<br>individualism<br>government<br>federal funding         |
| 308 | <b>PUBLIC PIONEERS.</b> William Goetzmann on the role of the Army in opening the American West.<br>From: <i>Army Exploration in the American West 1803-1863</i> by William H. Goetzmann (New Haven: Yale Univ. Press, 1963), pp. 59-61 and 372-374.<br>• 9-12. <i>History, Geography, Economics, Government, Social Studies.</i>  | 3 pgs  | exploration<br>engineer<br>army<br>west<br>federal funding        |
| 309 | <b>REALISTIC ROMANTICISM.</b> Richard Darman hails exploration as the key to renewing the American spirit and economy.<br>From: "Keeping America First: American Romanticism and the Global Economy." A Speech by Richard Darman at Harvard University, May 1, 1990.<br>• 6-8, 9-12. <i>Science, Economics, Government, Social Studies.</i>   | 10 pgs | romanticism<br>economy<br>spirit<br>exploration<br>environment    |
| 310 | <b>WHY WE EXPLORE.</b> NASA comments on the spiritual and social significance of planetary exploration.<br>From: <i>Solar System Exploration Division Strategic Plan, Vol. 1</i> (Washington, D.C.: National Aeronautics and Space Administration, 1991) pp. 8-10.<br>• 6-8, 9-12. <i>Science, Government, Social Studies, Psychology.</i>  | 2 pgs  | exploration<br>planet<br>NASA<br>Earth                            |
| 311 | <b>COST VS. BENEFITS.</b> President Eisenhower voices support for space exploration but concern about its costliness.<br>From: "Eisenhower: Why I Am a Republican" by Dwight D. Eisenhower in <i>The Saturday Evening Post</i> , April 11, 1964.<br>• 4-5, 6-8, 9-12. <i>Science, History, Government</i>   | 1 pg   | space<br>exploration<br>federal funding<br>prestige<br>government |
| 312 | <b>EXPLORATION AS THE KEY TO GREATNESS.</b> President   | 1 pg   | space   |

- Nixon says it is vital for America to continue to explore the unknown.  
 From: "Remarks of President Nixon Following a Tour of the Lyndon B. Johnson Space Center, March 20, 1974" in *Presidential Documents: Richard Nixon 1974, Vol. 10, No. 12*, (Washington, D.C.: U.S. Government Printing Office, 1974) pp. 345-346.  
 • 6-8, 9-12. *History, Social Studies, Psychology.*
- 313 **ON REACHING INTO THE UNKNOWN.** President Ford commends America's talisman spirit of adventure.  
 From: "Bicentennial of American Independence: President Ford's Remarks at the Dedication Ceremonies for the National Air and Space Museum, July 1, 1976" in *Presidential Documents: Gerald R. Ford, Vol. 12, No. 27* (Washington, D.C.: U.S. Government Printing Office, 1976) pp. 1105-1106.  
 • 4-5, 6-8, 9-12. *Science, History, Economics, Government, Social Studies*
- 314 **REMEMBERING APOLLO.** President Bush comments on the past and future dreams of U.S. space exploration.  
 From: White House press release, July 20, 1989.  
 • 6-8, 9-12. *Science, History, Government.*
- 315 **THE MOON LANDING NOW.** Mark Mullin, Headmaster of St. Albans, describes the impact of this milestone in human history and what it might mean for American education of the 21st century.  
 From: "Children of the Moon" in *Educating for the 21st Century: The Challenge for Parents and Teachers* by Mark H. Mullin (Lanham: Madison Books, 1991) pp. 1-12.  
 • 9-12. *Science, Economics, Social Science*
- 316 **COMPUTER EXPLORATION.** New trends and attitudes towards using educational technology.  
 From: "Voyages to Knowledge in Space Age" by Michel Marriott. Reprinted from *The New York Times*, May 5, 1990.  
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 • 3-5, 6-6, 9-12. *Science, Astronomy, Geography, Government, Social Studies, Psychology*
- 319 **FAR FROM THE GENETIC POLICE.** Remarks on the potential for human evolution in space.  
 From: "The Exploring Animal" by Ben R. Finney and Eric M. Jones in *Interstellar Migration and the Human Experience*, Finney and Jones, eds. (Berkeley: U. of Cal. Press, 1985) pp. 15-25. Copyright (c) 1985 The Regents of the University of California.  
 • 9-12. *Science, Biology, Social Studies, Psychology.*

- 320 **ENCOUNTERING THE ICE.** Historian Stephen Pyne provides a humanistic perspective on exploring Antarctica: it is what we make of it. From: *The Ice: A Journey to Antarctica*, by Stephen J. Pyne (Iowa City: University of Iowa Press, 1986) pp. 379-388. Copyright 1986 Stephen J. Pyne.  
 • 6-8, 9-12. *Science, Chemistry, English, Geography, Psychology, Art.* 1 pg exploration perspective ice Antarctica
- 321 **FACING THE FUTURE.** J. Robert Oppenheimer on the social history of science. From: "The Need for New Knowledge" by J. Robert Oppenheimer in *Symposium on Basic Research*, Dael Wolfle, ed. (Washington, D.C.: American Association for the Advancement of Science, 1959) pp. 1-15.  
 • 9-12. *Science, History, Social Studies* 8 pgs knowledge power science society choice
- 500 **The JASON Project.**  
 A national educational project to involve teachers and students in deep water scientific explorations. The goal is to provide students with a unique opportunity to take part in live scientific and archaeological exploration. JASON project scientists are interested in motivating students to study science, in deepening students' knowledge of scientific disciplines, and in strengthening students' critical thinking skills. The method is a "world classroom" made possible through Telepresence. Currently, the JASON project is set up in 20 sites (primarily museums) across North America. 6 pgs
- 501 **USA Today's Visions of Exploration: Past, Present, Future** 3 pgs  
 Developed in partnership with NASA, this innovative educational project is built around the themes of exploration and space. Using the USA Today newspaper, a curriculum guide, and lesson plans provided daily to teachers, the program seeks to connect historical and current events and to help children use that knowledge to explore social and technological issues of the 21st century. Though designed specifically to encourage student interest in science and space, this national project is interdisciplinary in approach.

- + 3220 Learning About Astronomy 0 items/no list  
 - 3221 Ray Villard's Astronomy Corner 24 items 10/14/92  
*We are living in a golden age of discovery. Because of the current explosion in knowledge, astronomy textbooks are outdated within just a few years of publication. This bulletin board provides brief news items to give you the latest news of current research in astronomy. These articles are suitable for use in classroom discussion at the middle and high school level. At the introductory astronomy college level they can be used as for homework assignments where students can evaluate the significance of the news item compared to textbook information.*

### **3221 Ray Villard's Astronomy Corner**

We are living in a golden age of discovery. Astronomers are making unprecedented advances in our understanding of the origin, evolution and dynamics of the universe. The pace of discovery is driven largely by the advent of space astronomy and powerful new ground-based telescopes.

Because of the current explosion in knowledge, astronomy textbooks are outdated within just a few years of publication. This bulletin board provides brief news items to give you the latest news of current research in astronomy. Many stories feature the findings from the Hubble Space Telescope and other NASA space astronomy

missions.

These articles are suitable for use in classroom discussion at the middle and high school level. At the introductory astronomy college level they can be used as for homework assignments where students can evaluate the significance of the news item compared to textbook information.

Send feedback on these articles to Ray Villard, Space Telescope Science Institute, 3700 Martin Drive, Baltimore, MD 21218, or by fax at 410-338-4579, or by email at villard@stsci.edu.

- 001 *This index* 4 pgs
- 301 "LIVING FOSSIL" STAR CLUSTERS 1 pg  
Using the high resolution of NASA's Hubble Space Telescope, astronomers have uncovered fifty young globular clusters in the core of a peculiar galaxy called NGC 1275, located 200 million light years from Earth.
- 302 A BACKYARD BLACK HOLE 1 pg  
M32 might contain the nearest example of a gigantic black hole—one weighing over three million times the mass of our sun. NASA's Hubble Space Telescope conclusively shows that stars are far more densely concentrated toward the nucleus than expected in a normal galaxy.
- 303 A MONSTER BLACK HOLE 1 pg  
Space Telescope shows that stars are far more densely concentrated toward the nucleus than expected in a normal galaxy. The best explanation is that the stars were drawn into the center by the gravitational field of a massive black hole.
- 304 A NEUTRINO TELESCOPE 2 pgs  
Today, telescopes are placed upon mountaintops and even into space to get a clearer picture of the universe. Now astronomers are planing a revolutionary new type of telescope that will look down instead of up. Placed on the ocean floor, off the coast of Hawaii, the new telescope will pick up energy from distant, exploding galaxies.
- 305 A ROGUE STAR 2 pgs  
Astronomers have now uncovered a remnant of a star that has been blasted into space, like shrapnel from a bomb. The runaway object is a neutron star, the compact core of a star the exploded as a supernova.
- 306 A ZOOM LENS IN SPACE 1 pg  
Hubble Space Telescope has found the equivalent of a huge magnifying glass in space. The combined gravity of all the galaxies in the cluster bends, concentrates, and focuses the light of more distant objects.
- 307 AN EMBRYONIC SOLAR SYSTEM? 1 pg  
For nearly a decade astronomers have been aware of a 100 billion-mile diameter disk of dust and gas around the star. The Space Telescope observations reveal a dynamic region which is no bigger than our inner solar system.
- 308 WATCHING THE WEATHER ON ANOTHER WORLD. 1 pg  
Space Telescope's high resolution pictures will allow astronomers

to observe Mars in detail almost whenever they want to. Space Telescope will help scientists predict such major martian weather events as global dust storms.

- 309 AURORAE ON JUPITER 1 pg  
Jupiter's magnetic field is far larger and more powerful than earth's, so the electrical fireworks which make aurorae are more spectacular too. Space telescope's ultraviolet sensitivity allows astronomers to filter out Jupiter's glare and focus on the aurorae, which glow brightly in ultraviolet light.
- 310 BORN AGAIN STARS 1 pg  
Now Hubble Space Telescope has come up with new clues to solving the blue straggler mystery. These stars might rejuvenate themselves and change from old stars back to young stars.
- 311 DEMOLITION DERBY ON JUPITER 1 pg  
Hubble Space Telescope's pictures of Jupiter reveal new surprises about the Red Spot. The spot pushed around smaller storm that got in it way. These small storms appear on Jupiter as white spots.
- 312 DIAMONDS IN SPACE 1 pg  
Astronomers first found microscopic diamonds in some meteorites samples in 1987. Ever since then researchers have wondered where the diamonds came from in space. Astronomers estimate that a nearby supernova which exploded in 1987 produced far more diamonds than all the grains of sand on earth's beaches.
- 313 DISTANCE TO A SUPERNOVA 1 pg  
Space telescope's sharp view provided an accurate measure the ring's angular size on the sky. This means the ring is more than one light-year across. The distance to the supernova, and its host galaxy, the large Magellanic Cloud, turns out to be 169,000 light years.
- 314 EXTRAGALACTIC JETS 1 pg  
Astronomers suspect that a gigantic black hole, at a galaxy's core, might be the powerhouse behind an extragalactic jet. When seen with Space Telescope's new level of detail, two extragalactic jets observed so far have remarkably different structure.
- 315 GAMMA RAY BURSTS 1 pg  
The Gamma Ray Observatory discovered that these incredibly powerful gamma ray bursts occur about once a day. Based upon these early observations, researchers speculate that at least one million neutron stars inhabit our galaxy.
- 316 GAMMA RAY QUASARS 1 pg  
The ultra-high energy beams were detected by NASA's Gamma-ray observatory as coming from quasars, the most distant objects in the universe. These new gamma-ray quasars show the universe if more dynamic and violent than previously imagined.
- 317 HALO FOR A DEAD STAR 1 pg  
Supernova 1987A was one of the first targets for NASA's Hubble Space Telescope. The space observatory uncovered a ghostly

"footprint" of the original star, the one there before the supernova erupted.

- 318 INTERGALACTIC CLOUDS 1 pg  
Astronomers expected that these primordial clouds became more sparsely scattered as the universe evolved to our present time. So it came as a surprise when NASA's Hubble Space Telescope found some of these clouds in our own galactic back yard, less than a billion light-years away.
- 319 ON THE TRAIL OF A BLACK HOLE 1 pg  
Astronomers recently looked at the location of the suspected black hole that caused the 1991 nova. They found a star like our sun. The star whirls about and invisible companion two and a half times per day at one million miles per hour. A black hole is the most likely explanation for such a massive yet compact object.
- 320 STARS ON THE REBOUND. 1 pg  
NASA's Hubble Space Telescope is peering in the core of globular star clusters to reveal what happens when stars are so tightly crammed together. The space telescope observations suggest that the core is actually on the rebound, like a rubber ball that has been squeezed and then relaxed.
- 321 THE CASE OF THE MISSING GALAXIES 1 pg  
Astronomers have found many faint galaxies lying billions of light-years away. These so called dwarf galaxies are much smaller than galaxies like our Milky Way. The mystery is that very few of these galaxies exist today. So where did they go?
- 322 THE DOOMSDAY ROCK 1 pg  
It's not a question of if the Doomsday Rock will strike, its only a question of when and where. Unlike the dinosaurs we do possess the capability of avoiding our own destruction.
- 323 WAS MARS ONCE A BLUE PLANET? 2 pgs  
billions of years ago Mars was warmer, wetter, and had a thicker atmosphere. Mars was very much like Earth. As carbon dioxide dwindled, so did Mars' warm climate. A global ice age now entombs the planet.

+ 3300 Teaching Units

0 items/no list

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+ 3310?

- 3311 The Hubble Space Telescope
- 3312 Asteroids, Collisions, and Craters

0 items/no list

1 item 12/01/92