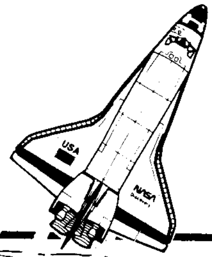
NASA
National Aeronautics and
Space Administration

Teacher in Space

Teacher in Space Project



YOUR INVITATION FROM SPACE...Come aboard for a history-making educational opportunity to instruct using the first lessons taught live from the Space Shuttle. Teacher in Space, Christa McAuliffe, will teach two lessons that will be broadcast live via satellite to the classrooms and homes of television viewers from the Shuttle Challenger. The materials in this publication have been designed to help teachers and other adults maximize the learning experiences which will grow from the lessons and other educational events scheduled on Mission 51-L's historic flight!

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PROJECT BACKGROUND

Plans to make a teacher the first private citizen to fly on the Space Shuttle began with President Ronald Reagan's announcement of the program on August 27, 1984. Christa McAuliffe will fulfill that decision on Shuttle Mission 51-L slated for launch in January 1986. McAuliffe's flight is a part of NASA's Space Flight Participant Program which is designed to expand Shuttle opportunities to a wider segment of private citizens. Among her challenges will be communication of the experience and flight activities to the public through educational and public information programs.

The selection of Christa McAuliffe as primary candidate and Barbara Morgan as backup culminated a search process coordinated for NASA by the Council of Chief State School Officers. Some 11,000 teachers applied for the opportunity to become the Teacher in Space. State, territorial, and agency review panels each selected two nominees for a nomination slate of 104. These nominees are continuing to serve as NASA's educational Space Ambassadors in their areas.

The ten finalists announced on July 1, 1985 traveled to NASA's Johnson Space Center in Houston, Texas and Marshall Space Flight Center in Huntsville, Alabama for briefings and testing. A NASA Evaluation Committee interviewed them in Washington, D.C., and the final selection announcement was made by Vice President George Bush on July 19, 1985. Christa McAuliffe and Barbara Morgan began their training on September 9 at the Johnson Space Center.

The remaining eight finalists are working with NASA on a one-year assignment at Headquarters and NASA research centers. In August, they worked with McAuliffe and Morgan to design the lessons which the Teacher in Space will teach live during the mission. Their continued input will create an abundance of new space-related materials for the classroom.

MISSION BACKGROUND

The Crew:

Commander—Francis R. (Dick) Scobee

Pilot—Michael J. Smith

Mission Specialist—Judith A. Resnick, Ph.D.

Mission Specialist—Ellison S. Onizuka

Mission Specialist—Ronald E. McNair, Ph.D.

Payload Specialist—Gregory Jarvis (Hughes Communications)

Space Flight Participant (Teacher-Observer)—S. Christa McAuliffe

The Flight, Payload, and Experiments:

Shuttle Mission 51-L will be a six-day mission. Launch is scheduled for January 22, 1986 from the Kennedy Space Center, and landing is scheduled for January 28 at the same site. The mission carries two major payloads, the TDRS-B (Tracking and Data Relay Satellite-B) and the Spartan-Halley carrier. On the first flight day, the crew will deploy TDRS-B; on the third flight day, the Spartan-Halley carrier, which will be retrieved on the fifth flight day. In addition, the crew will be conducting and monitoring a series of scientific experiments during the Mission. McAuliffe may describe these activities during her live lessons from space.

Payload:

The TDRS-B will join TDRS-1 in geosynchronous orbit to provide communication and data links with the Space Shuttle and satellites. TDRS-2 (WEST) will be stationed over the Pacific; TDRS-1 (EAST) is stationed over the Atlantic.

The Spartan (Shuttle Pointed Autonomous Research Tool for Astronomy) mission is designed to observe the ultraviolet spectrum of Comet Halley. Two ultraviolet spectrometers will be mounted on the Spartan carrier which will scan the tail of Halley on each of its orbits. The Spartan will be deployed and retrieved with the Remote Manipulator System (RMS) and stowed in the payload bay for the remainder of the Shuttle flight.

The Shuttle Student Involvement Program, a competition managed by the National Science Teachers Association with NASA to encourage student-designed experiments that can qualify to fly on missions, will be flying three experiments on this mission:

A. *Chicken Embryo Development in Space* by John C. Vellinger of Lafayette, Indiana.

B. *The Effects of Weightlesness on Grain Formation and Strength in Metals* by Lloyd C. Bruce of St. Louis, Missouri.

C. *Utilizing a Semi-Permeable Membrane to Direct Crystal Growth* by Richard S. Cavoli of Marlboro, New York.

PREFACE

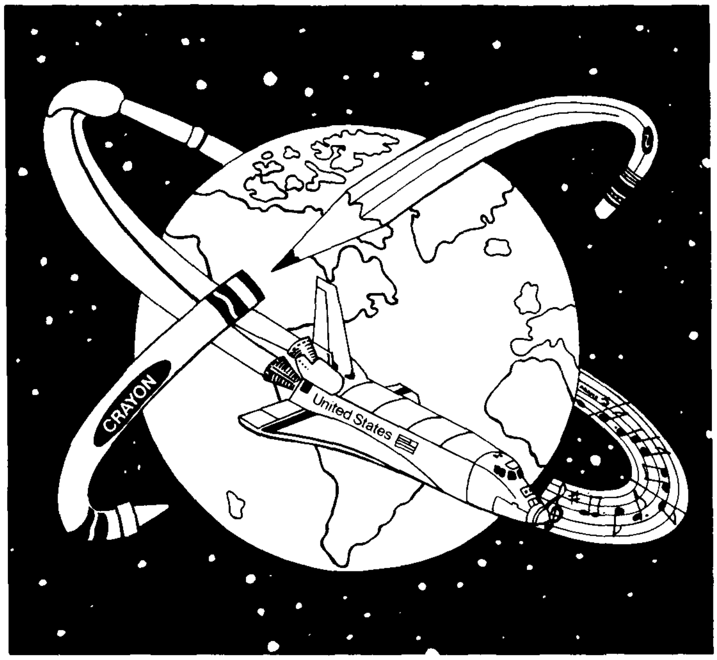
NASA is pleased to provide this Teacher's Guide to extend the learning experiences evolving from the Teacher in Space Project. The publication is the product of a team effort by NASA, the National Science Teachers Association (NSTA), the National Council for the Social Studies (NCSS), and curriculum professionals. It is based upon ideas contributed by the Teacher in Space finalists, the Space Ambassadors, and other practicing teachers.

We have sought to publish practical and mind-stretching teaching ideas, plans, and resources for a variety of curriculum areas and grade levels — all growing from aspects of Mission 51-L. The capsules and detailed activities are concept-based and are designed to strengthen critical thinking and problem-solving skills. We hope this Guide will help all of you, the people who teach live on Earth every day.

NASA wishes to thank the following individual teachers who wrote activities for this Guide: Charles Frederick, Marilyn Kirschner, Beverly Sutton, and Howard White. We wish to acknowledge the contributions of the following: William D. Nixon, Teacher in Space Project Manager; Dr. Doris K. Grigsby and Muriel M. Thorne of NASA Headquarters Educational Affairs; Dr. Helenmarie Hofman, NSTA; Frances Haley, NCSS; and Dr. June Scobee, University of Houston–Clear Lake. We also thank Joan Baraloto Communications, Inc. for coordinating the preparation, development, and publication of this guide.

Thomas P. DeCair

Thomas P. DeCair/Associate Administrator for External Relations, NASA



DESCRIPTION OF THE LIVE LESSONS

The Ultimate Field Trip

This lesson is based on a quotation by Teacher in Space Christa McAuliffe who described her opportunity to go into space as "the ultimate field trip."

Viewer Objectives:

1. To observe the major areas of the Shuttle and describe their functions
2. To list and describe the major kinds of activities crewmembers perform aboard the Shuttle
3. To compare and contrast daily activities in microgravity with those on Earth

Video Lesson Description:

This lesson from space will begin in the flight deck area of the Challenger where Christa McAuliffe will introduce the commander and pilot and will point out the Shuttle controls, computers, and payload bay.

When she arrives at the middeck, McAuliffe will show viewers the kinds of equipment and processes which help human beings live comfortably and safely in the microgravity environment of the Shuttle.

Where We've Been, Where We're Going, Why?

Viewer Objectives:

1. To explain some advantages and disadvantages of manufacturing in a microgravity environment
2. To describe spinoffs and other benefits which have evolved from the space program
3. To list ways in which the modular Space Station would change the lives of human beings

Video Lesson Description:

As this lesson from space begins, Christa McAuliffe will refer to models of the Wright Brothers' plane and of a proposed NASA Space Station to help viewers recall that only 82 years separate that early flight and today's life in space.

McAuliffe will discuss the reasons we are living and working in space, covering astronomy, Earth observations, experiments on-board the Shuttle, satellites on the mission, materials processing, and technological advances.

TEACHING-RELATED EVENTS OF MISSION 51-L

Live Lessons:

As part of the 51-L Mission, the Teacher in Space, Christa McAuliffe, will teach two live lessons from space. These lessons are currently scheduled on the sixth day of the Mission at 11:40 a.m. and 1:40 p.m. Eastern Standard Time.

PBS Broadcast:

The Public Broadcasting Service (PBS) will carry both lessons via Westar IV. PBS will offer the programs to member stations that will be requested to preempt regular classroom programming to carry the lessons live. Specific information about the PBS transmission may be obtained from local PBS stations or by writing to Elementary and Secondary Programs, PBS, 475 L'Enfant Plaza, SW, Washington, D.C. 20024 or calling 202/488-5080.

Mission Watch (Satellite Broadcast to Schools):

NASA will make available to schools equipped with satellite dish antennas daily activities conducted aboard the 51-L Mission. This effort will be coordinated by Classroom Earth, an organization dedicated to direct satellite transmission to elementary and secondary schools. Participating schools will receive in advance educational materials, television schedule, orbital map, Shuttle Prediction and Recognition Kit (SPARK), and other information that will prepare teachers and students to follow all aspects of the 51-L Mission. Barbara Morgan, backup candidate, will act as moderator for these daily special broadcasts. Specific information related to "Mission Watch" is available by writing to Classroom Earth, Spring Valley, IL 61362 or by calling 815/664-4500. Information can also be accessed on the National Computer Bulletin Board (300 baud) 817/526-8686.

Filmed Activities:

In addition to live lessons, McAuliffe will conduct a number of demonstrations during the flight. These filmed activities will be used as part of several educational packages to be prepared and distributed after the Mission.

KEY MISSION-RELATED TERMS

Comet Halley — comet which reappears near Earth approximately every 76 years

Communication satellite — orbiting spacecraft which sends messages, connects computers, and carries radio and television programs via microwaves

EMU (Extravehicular Mobility Unit) — space suit with its own portable life-support system

51-L — number of the Mission carrying the Teacher in Space project

Flight deck — upper Shuttle deck housing the controls and computers for the commander and pilot

Geosynchronous orbit — path 35,680 km from Earth in which a satellite's speed matches exactly Earth's rotation speed, so that the satellite stays over the same location on the ground at all times

Microgravity — 1/10,000 of the gravity force on Earth

Middeck — living and work area of Shuttle located below flight deck

Mission control — a room at the Johnson Space Center in Houston, Texas from which the crew's activities are directed

Mission specialist — scientist on crew responsible for experiments and deploying satellites

Mission Watch — daily satellite program transmission highlighting Mission events

NASA — National Aeronautics and Space Administration

Orbiter — reusable manned component of Space Shuttle; there are four; Mission 51-L uses Challenger

Payload — cargo; equipment

Payload bay — large section of the Shuttle where the payloads are stored

Payload specialist — scientist named for flight by a company or country sponsoring a payload; specialist is certified for flight by NASA

Principal investigator (PI) — scientist who designs and directs a mission experiment

Simulator — training equipment which gives trainees opportunities to experience flight-like activities and sensation

Space Shuttle — four-part vehicle: a reusable orbiter, an expendable liquid propellant external tank, and two recoverable and reusable solid rocket boosters

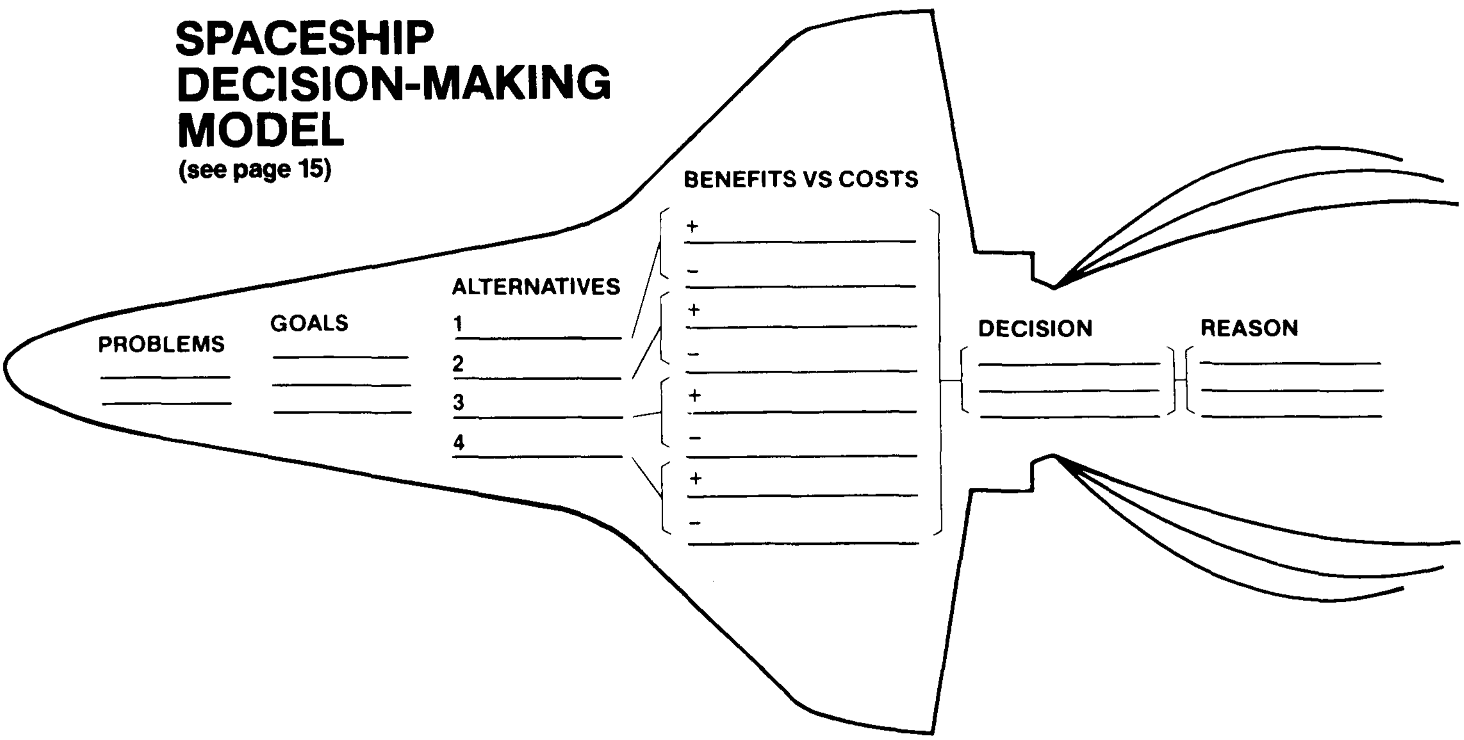
Spartan-Halley — payload designed to make observations of the ultraviolet spectrum of Comet Halley

Spinoffs — useful applications of space technologies different from their original aerospace function

TDRS (Tracking and Data Relay Satellite) — a communication satellite deployed by NASA for its communication system

SPACESHIP DECISION-MAKING MODEL

(see page 15)



PRE-VIEWING ACTIVITIES

● Provide enlargements of the illustration of the Space Shuttle from this Guide or other sources. Explain that the teacher-observer is part of a seven-person crew living in that Shuttle. Ask students to focus on "The Ultimate Field Trip" lesson, to estimate the Shuttle's size, and to describe as many details of the living space as possible.

Use a globe and model or picture of the Shuttle to demonstrate the location of the Shuttle above Earth's surface. Have students relate the distance of the spaceship above Earth to ground distances familiar to them, e.g., the Shuttle is orbiting at least 115–190 statute miles above Earth's surface — a distance between your community and ________. Talk about how Earth looks from that distance.

● Tell students that they will be seeing the teacher-observer as she speaks from the Space Shuttle. Theorize with them about how that will be possible. Introduce the idea of communication satellites and ask them to watch for information about satellites.

Focus students' thinking on the kinds of planning it may take for a mission to be successful. Discuss the roles of the ground and Shuttle crews in performing experiments. Think about applications of the experiments after 51-L.

● The Teacher in Space is the first private citizen in space. When President Reagan announced the NASA Space Flight Participant Program, he emphasized that the private citizen chosen to fly a mission would have the job of communicating the experience and flight activities to the public. Discuss why the first private citizen is a teacher. Discuss the duties and sense of responsibility placed upon her. Have students list some experiments they would like to see her demonstrate in the microgravity environment. Have them provide the rationale for their choices.

Explain that the Teacher in Space is keeping a journal of her experiences. Ask students to describe the kinds of information they think she should include in it.

● The commercial world anticipates many benefits from manufacturing in space. Ask students to think about how microgravity could actually help the manufacturing of certain products.

One of the justifications for the space program has been the many benefits of direct applications of ideas and products to life on Earth. McAuliffe will explore some of the newest experiments. Ask students to be watching for ways these experiments might help human beings on Earth.

● Brainstorm with students the titles and collections of space-related music. Collect the albums or tapes and play them as background music during the week of Mission 51-L. Possible titles: *The Planets* by Gustav Holst; *Pops in Space* and *Out of This World* by John Williams and the Boston Pops; the soundtracks from *E.T.*, *Close Encounters of the Third Kind*, the *Star Wars* trilogy, *2001*, and the PBS television series of *Spaceflight*; Handel's *Royal Fireworks Music*; and *Ionization* by Varèse.

Prepare a list of authors, stories, books, and poetry that deal with space. (See Resources.) Read selections with students each day of the Mission.

● Before reading the following passage to students, explain that it was read aloud from space by Astronaut Jeff Hoffman during his April 1985 mission. The prose was written by French writer, René Daumel, in his book, *Mount Analog: NonEuclidean Adventures in Mountain Climbing*. Discuss with students what the surrealist Daumel may have meant when he first wrote the words in the 1920s. Then discuss possible applications of the words to spaceflight. Why would an astronaut choose to carry these thoughts with him into space? "You cannot stay on the summit forever, you have to come down again. So why bother in the first place? Just this. What is above knows what is below, but what is below does not know what is above. One climbs. One sees. One descends. One sees no longer. But, one has seen. There's an art of conducting oneself in the lower regions by the memory of what one saw higher up. When one can no longer see, one can at least still know."

Obtain a SPARK KIT (Shuttle Prediction and Recognition Kit). See Resources. Step outside with your students to gaze at the first outer space classroom — the Space Shuttle, home to Teacher-Observer Christa McAuliffe. The easy-to-follow booklet will let you and your students learn how to locate the Shuttle on any of its orbits around Earth and to predict when it can be seen from your community.

● Discuss with students the special problems of meeting survival needs in space. Explain that in addition to those described by McAuliffe during the live lessons, the students may want to read about special needs and solutions for space. Assign students to research and report on the areas of needs and how they are met.

Have students prepare a list of items they might like to take on the Shuttle to use in their leisure time. Ask them to explain the importance of each item selected.

● Encourage students to imagine that they are on the crew of a future spaceflight. Have them describe a problem that arises, how the crew might resolve it, and the role of the individual in the solution. Have them write their composition in narrative style.

Set up a tent in the classroom and assign various activities that will help students experience working in a confined space.

● Ask students to think about their home kitchens and meals. Ask them to talk with families about items that were not there before the students were born. Make a class list of these items and processes. Students may like to write a time warp story about a person from the 1960s who shows up in a kitchen of the 1980s or the year 2000.

Display several items such as a digital watch, calculator, microcomputer, plastic meal pouch, or Velcro fastener. Ask students to link the items to the space program. Classify them as benefits or technological spin-offs of space technology. Emphasize that when Congress established NASA in 1958, one of the goals was to have the space agency seek to transfer space technologies to everyday life. Today's benefits are accessible through NASA's Technology Utilization Program.

● Benefits related to aerial photography via satellite are also of interest to students. Some may want to explore detecting oil slicks at sea, charting glaciers, forecasting spring runoffs for irrigation, inventorying standing timbers and grasslands, evaluating flood damage, checking environmental impact of strip mining, analyzing the gypsy moth, detecting potential earthquake zones, and mapping land and water uses.

Concept: The size of the middeck and payload bay areas of the Shuttle helps determine the crew's activities and the payload.

● Ask students to imagine that they have been chosen for a space mission. Have them list items they would take as mementoes. Then inform them that their Personal Preference Kits must be limited to 20 separate items weighing a combined total of 680 grams (1.5 pounds). Ask them to eliminate all overweight articles and list only the items they consider most important.

Have students suggest some familiar large payload objects for the cargo bay to gain an idea of comparative size, i.e., a trailer truck (18-wheeler), a railroad boxcar, a tank car, or a bowling alley.

● Obtain large discarded cardboard boxes used to ship appliances to build a model of the middeck. Let students measure, cut, tape, and build a walk-in model of the middeck. Invite other classes to see these examples of "cardboard carpentry."

Many teachers are using a process approach to writing with their students. In one of its earliest stages students prepare to write by charting words and relationships on paper. Given the topic "Everyday Life on Mission 51-L," build a "word web" or idea chart on the chalkboard. Assign students to choose the best ideas to write a paragraph on the topic.

Objectives:

1. To simulate the amount of space available to the crew on a Shuttle mission by measuring and laying out the dimensions of the middeck and payload bay

2. To physically experience the amount of space available in the middeck and payload bay areas

1. Remind students of the Teacher in Space's tour of the Shuttle. Explain that they will be laying out the size and shape of the Shuttle on a parking lot or blacktop area (chalk), playing field (lime or mowing), snowy field (dye). Middeck dimensions may be laid out in the classroom; payload bay, in the school hallway.
2. Assign groups to make specific measurements of the following interior dimensions of the Shuttle on the surface you have selected:

   a. Overall length of the middeck, 4.00 m (13.1 ft.) plus the payload bay, 19.7 m (60.00 ft.) totals a continuous length of these two working interiors of 23.7 m (73.1 ft.).

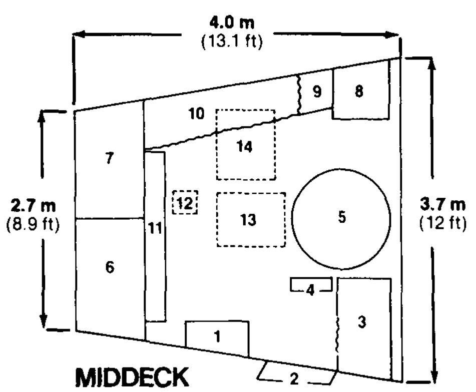
   b. At right angles to the length, beginning at the front end, mark off the height of the middeck, 2.1 m (6.89 ft.).

   c. At the terminal end of the middeck (which has an airtight structural wall), measure the height of the payload bay 4.56 m (15.0 ft.). The increase in height of the payload bay should rise above the middeck height since the commander/pilot flight deck is on top of the middeck. (See Illustration below.) Measure and mark this height, 4.56 m (15.0 ft.), at intervals along the entire length of the payload bay.

   d. Use some technique to outline the length and height of the middeck and payload bay. You now have the crew's working area (middeck) and the payload bay.

   e. To show the trapezoidal-shaped floor space available to the crew when the Shuttle is on the ground, use the same 4.00 m middeck length and mark off these widths for the floor plan: 2.7 m (8.9 ft.) at the front, expanding to 3.7 m (12 ft.) at the rear. This floor plan area is filled with hundreds of items precisely arranged to maximize efficiency and minimize discomfort for the crew. (See Illustration below.)

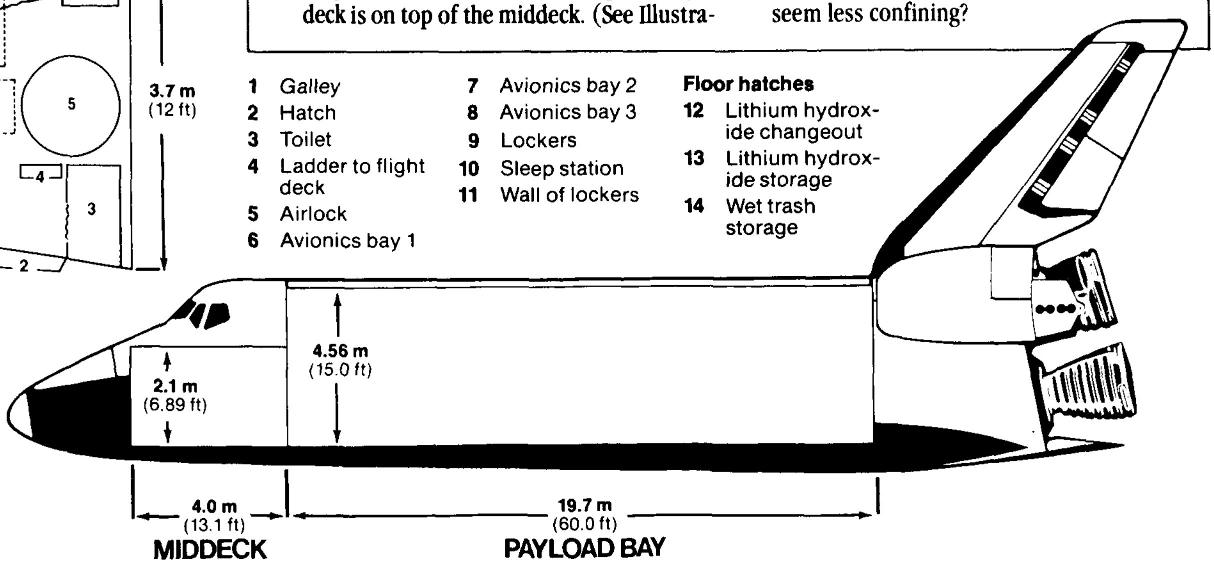
   f. The payload bay's floor plan is the same as that laid out in 2.c. above because the height of the bay, 4.56 m (15.0 ft.), is also its width.
3. Have seven students stand on the floor plan of the middeck and see how much area each student has. How does this area compare with rooms in a home? Tell students to imagine this middeck floor plan area also holding large equipment. (See Illustration below.) Have students now estimate the available space for crewmembers with equipment in place. Could microgravity during orbit increase their options? How? Have students calculate the volume of the middeck. Does the maneuverability of weightlessness make the middeck quarters seem less confining?



MIDDECK FLOOR PLAN

1 Galley
2 Hatch
3 Toilet
4 Ladder to flight deck
5 Airlock
6 Avionics bay 1
7 Avionics bay 2
8 Avionics bay 3
9 Lockers
10 Sleep station
11 Wall of lockers

Floor hatches
12 Lithium hydroxide changeout
13 Lithium hydroxide storage
14 Wet trash storage



Concept: Planning for life on extended Shuttle missions or in Space Stations must consider the effects of Orbital Human Factors (OHF) on people's behavior.

● Have students work individually or in small groups to study the following questions:

a. What are the physiological effects of microgravity?

b. Why is exercise so important in microgravity?

c. What is space sickness? How might it affect the crew's performance? How is it being treated?

Circadian rhythms are another consideration when planning space missions. Circadian rhythm is the cycle of wakefulness and rest that each individual experiences. Most people operate on a 24- to 25-hour cycle with six to eight hours of sleep included in the cycle.

a. *Have students locate general information regarding the crew's schedule in space.*

b. *Direct students to chart their own circadian rhythm for one or two weeks. Each day, they should record their times of sleep, peak activity, and relative inactivity. Compare these charts with those schedules maintained by flight crews.*

c. *Have students compile information about the effects of shift work on humans, the scientific explanation of "Monday morning blues," and how much sleep actually is required by most people. Invite a psychologist or medical doctor to discuss sleep.*

● Ask the class to explain why it is necessary for most people on Earth to recline in order to sleep well. Then compare this sleep behavior on Earth to sleep in microgravity. (See Illustration right.) Emphasize the changes in sleeping arrangements in microgravity where there is no need to recline.

Discuss with students the kind of psychological atmosphere among the crew that would be necessary to function for six to nine days in these small living/working quarters where every waking and sleeping hour is programmed.

a. *What kinds of preparation might be needed in pre-flight training to ensure a smoothly working team?*

b. *What other kinds of high performance teamwork might be as demanding on Earth?*

Have students design recreational activities which would be suitable for a microgravity environment.

● Several of the seven crew members on Mission 51-L have a strong interest in the arts. Commander Scobee enjoys oil painting and woodworking; Pilot Smith does woodworking; Mission Specialist Resnick is a classical pianist; Mission Specialist McNair is a performing jazz saxophonist; Space Flight Participant McAuliffe plays the guitar and piano and enjoys singing; and backup candidate Morgan plays the flute and violin. Ask the students how the crew might pursue their interests during flight. Discuss why it is important to have outside interests. Ask them to list some of theirs and to discuss the benefits they receive by being a member of the team, club, or group.

Have students describe their favorite at-home and at-school activities. Could they be able to enjoy them during a spaceflight? Have them consider a substitute leisure activity.

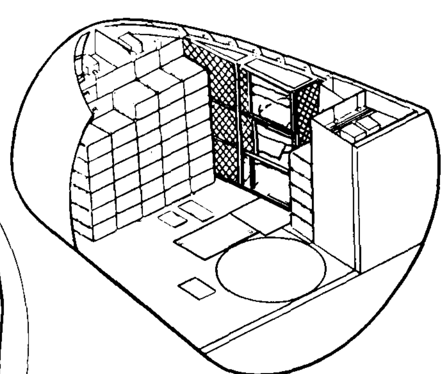
● Make a class mural that includes a self-portrait of each student doing his/her favorite leisure activity on the Shuttle. Allow students to include only those which would work in small spaces and in microgravity.

Each member of a Shuttle crew has a portable stereo cassette with earphones and may take six 60- or 90-minute tapes of music on a flight. Have students select six albums or tapes that they would take and write a paragraph explaining their choices. Ask them to listen to only that music during the 51-L Mission. At the conclusion of the flight have them write their reactions to their selections: Would they make the same choices again? Why or why not?

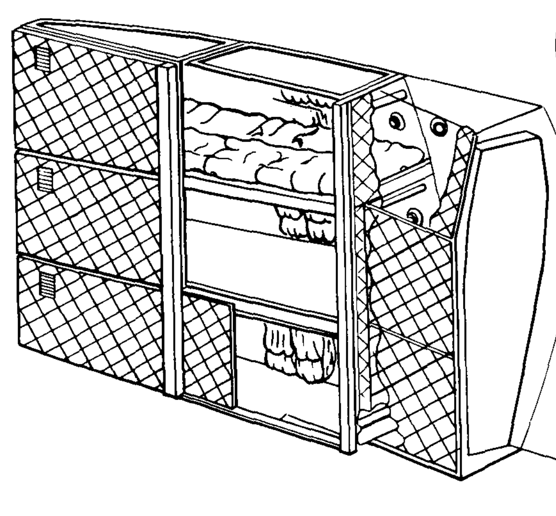
● Arctic and Antarctic explorers have kept detailed records of the influences of an isolated environment and cold on human behavior. Challenge students to research their writings and report to the class on parallels between their ideas and Orbital Human Factors. Discuss whether similar parallels might be drawn with explorers of other territories.

Ask students to interpret what Isaac Asimov meant when he said, "Throughout the history of humanity, we have been extending our range until it is now planet-wide, covering all parts of Earth's surface and reaching to the bottom of the ocean, to the top of the atmosphere, and beyond it to the Moon. We will flourish only as long as we continue that range, and although the potential range is not infinite, it is incredibly vast even by present standards. We will eventually extend our range to cover the whole of the solar system, and then we will head outward to the stars." —Isaac Asimov in "Our Future in the Cosmos—Space," NASA Conference

Have students write position papers based on this quotaton. Ask them to defend or refute the idea of limiting our exploration to Earth. Ask how they define "our world."



Middeck



Sleeping System on Shuttle

Concept: Space crews follow specific routines for meeting health and survival needs in space.

- Describe and demonstrate the small space (4 m × 3.7 m × 2.7 m) of the middeck in which the spaceflight crew lives. Have students list the basic needs they think might have to be met in order to survive a seven-day period in a microgravity environment. Ask them to explain and defend their choice.

Plan a day's menu which meets the daily food requirements. Determine how to prepare the foods for storage, how they will be stored, and how they will be prepared. Plan a five-day menu which can be stored in a child's backpack. Compare the space utilization (volume) and weight of dehydrated foods such as instant soup, orange drink, and dried apples with their rehydrated counterparts. Make a graph showing the results.

- Visit or read about a ship's galley. Compare and contrast it with the galley on the Challenger.

When people colonize space, it will be necessary for them to produce some of their own foods. Discuss the implications of food production in space.

- All clothing for the crew, except underwear, is the same for both sexes and includes cotton pants, shorts, tee shirts, flight jackets, short sleeved shirts, and slipper socks. Crew members frequently move around their Shuttle environment and they need to carry and use pens, flashlights, scissors, fork, kneeboards (for notes), and a checklist. Ask students to design clothing to accommodate movement and accessories. Have them consider both vehicular and extravehicular needs. How will their clothing differ from that which is worn on Earth?

Astronauts have recorded evidence that they grow at least 2.54 to 3.81 cm (1 to 1½ in.) very soon after they are in a microgravity environment. Their space suits are designed to accommodate this temporary growth. Discuss with students why the body grows and how the spaces between the vertebrae expand in space. Research body fluid shifts in microgravity. How does this affect clothing requirements?

- Logos are symbolic representations of the major goals of a spaceflight mission. Ask students to imagine that the class has been assigned to a spaceflight. Have them design and prepare a logo for use on their clothing to designate that mission.

Exercise is needed on a spacecraft so that bones and muscles will not deteriorate on long missions. In an apparent weightless state, bones and muscles do not experience the same resistance as in gravity. Have students compare their exercise regimens with the recommended 15 minutes per day treadmill workout on the Shuttle. Discuss why doctors have patients up and walking as soon after surgery/illness as possible.

- Have teams of students take blood pressures and pulse rates before and after three minutes of vigorous exercise, determine the time needed to return to normal pulse rate, and record all data. Invite a doctor/school nurse/instructor to help students interpret the results. What variables might effect changes in pulse rate/blood pressure during and after a spaceflight?

Ask students to prepare a list of exercises they could not do in space and the reasons why they could not be done.

- Shuttle crew members are allocated as much as 2800 calories each day of the mission. Challenge students to decide whether they think the crew would need more or fewer calories in space than on Earth. Have them explain and support their decision.

Explore the following thought questions as they relate to similar needs in space.

a. How does the Shuttle crew's health maintenance routine compare with that of the crew of a submarine on active patrol?

b. What kind of balanced diet, exercise, and sleep routine do you need to do your best in your sports/academic life?

- Show students a picture or model of the Orbiter. Explain that there are systems aboard the spaceship to help keep it functioning and to keep the crew alive. Discuss each of the six systems with the class: food supply, air, water, waste disposal, power, and communications. Assign a group to each of the six systems to begin a chart with the following headings: **a.** Name of System, **b.** Need for the System, **c.** Possible Problems if System Does Not Function, e.g. spoiled food, loss of oxygen, fire, **d.** Alternate Solutions. Have groups report their findings to the class.

Have students investigate problems encountered and resolved in earlier spaceflights. Consider, for example, Solar Max repair (STS 41-C) and the Syncom satellite repair (STS 51-D). Ask students to write expository essays explaining the problem-solving activities in space.

Objective: To compare the Shuttle crew's needs in space with those needs on Earth in terms of caloric intake, exercise, and sleep

1. Talk with students about how they maintain their health by eating, exercising, and sleeping.
   a. Develop an efficient record-keeping chart for each student to record the following data:
      1) name, day, date, and hours of sleep;
      2) each meal's items and approximate number of calories and total calories for the day
      3) type and amount of exercise all day
   b. Provide the following information on daily needs of the Shuttle crew:
      1) food/calories — (approximately 2,800 Calories)
      2) exercise — (15 minutes on treadmill or its equivalent)
      3) sleep — (8 hours)
2. Review the kinds of foods used on a space mission. Describe a typical daily menu. Compare an astronaut's menu with a student's menu. If possible, compare and contrast them as to processed or natural foods. Compare calories.
3. Compare students' records for exercise and sleep with crew's requirements in space.

Concept: A Space Station is designed to serve a variety of functions for technological study and development that will benefit all humankind.

● Ask students to recall different kinds of space stations from science fiction stories they have read or movies they have seen (Battlestar Gallactica, the Star Wars Empire, the Star Trek Federation). Emphasize that these are fictional versions of something that has never existed, but that the Space Station will soon be a reality.

The Space Station will fulfill eight major functions: living area, laboratory for science and technology, permanent observatory of Earth, servicing for spacecraft, station for space vehicles and payloads, manufacturing facility, storage depot, and staging base for future space activities. Divide the class into small groups to study each of the Space Station functions. Ask the groups to describe the possible details of their function, to compare it to a place or activity we know on Earth, and to describe how they think it will look with words and illustrations. Have the groups report and combine all illustrations into a giant collage or flow chart entitled "Our Future Home." (See Illustration below.)

● President Reagan's plans include international cooperation in the development and use of the Space Station. Discuss this potential international colony in space.

Reasons for establishing a space station may include adventure, trade, freedom, growth of new technology, commerce, transportation, and manufacturing. Have students suggest other reasons for space colonization.

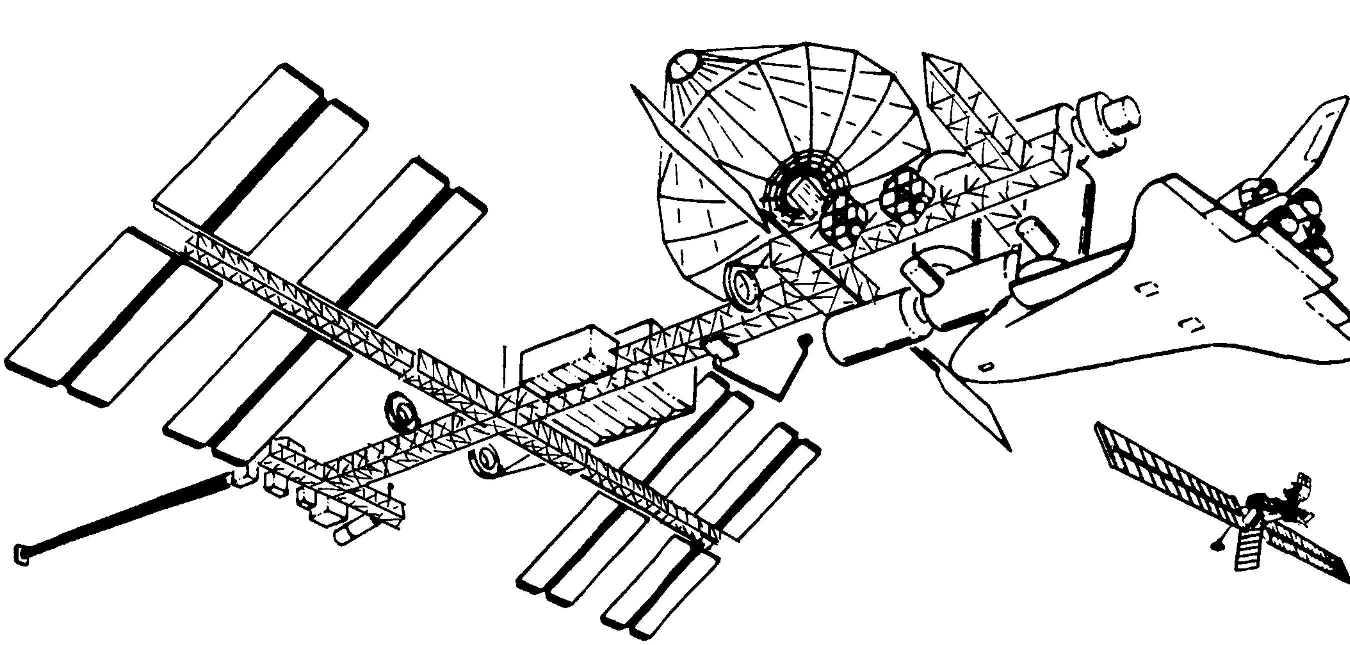
● Challenge students to predict how people from Earth will get to the Space Station, how long they will stay, and how they will return. Ask them to pretend that tickets will go on sale in the year 2000. Have them imagine what they will be doing and whether they or anyone they know will go. Predict whether the Station will admit only workers or whether visitors will be allowed.

Assign each student to write a first-person account of a new inhabitant of the Space Station. Have the students describe their trip, their new living quarters, and their work. Share the compositions.

● The Space Station concept will be reality for your students in their lifetimes. Talk with them about the kinds of activities and responsibilities which will be required on a Space Station. Ask them to pretend that they have an opportunity to apply for a job on the Station. Have them write their letter of application to the space personnel office to apply for the job of their choice.

Challenge students to consider the following question: Will migrations from Earth to Space Stations and other planets be similar to the migrations from Europe at the turn of the century? Ask students to compare our future space settlers and pioneers to the early settlers and pioneers of America. After a brainstorming session, have students organize their ideas for a composition based upon comparison/contrast.

● Hypothesize with students that they have been given the responsibility of planning a Space Station community. They may be like the planners of some of America's famous planned communities or towns. Ask them to list the institutions, services, jobs, activities, recreation, and other details their community would have. Make a large flow chart to show the relationship of the community's components.



A Space Station Concept

Concept: A diversity of jobs is required to plan, build, operate, and maintain a spacecraft.

● Distribute pages of classified advertisements to the class. Divide the class into small groups to write want ads for each of the jobs on the crew of 51-L. Post the ads. Discuss whether they know of individuals who could meet the qualifications they set.

Philip Morrison, Professor of Physics at the Massachusetts Institute of Technology, speaking at a NASA symposium in 1976, said, "... it seems to me the imagination has not yet succeeded in conveying to people in general what kind of role one can have in today's complex exploraton. Very many are the indispensable porters, and only very few are the intrepid mountaineers." Have students apply this to Mission 51-L and the space program.

● Ask students to think about their interests and to choose two jobs related to space that they think they would like to do; research the skills and training necessary to fulfill the jobs; draw up job applications; apply for jobs in space; and go through a preliminary screening and interviewing process to select two candidates for each job.

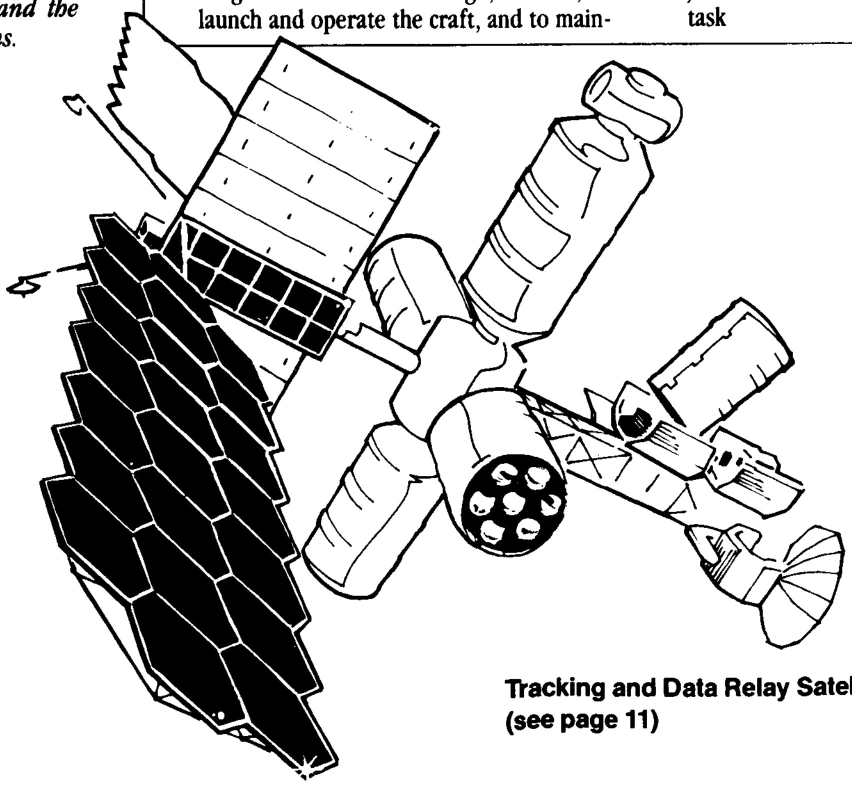
Interpersonal cooperation is a critical element in a successful mission. Discuss the kinds of personal qualities that individuals chosen for a mission must have and the qualities which might cause problems.

Objectives:

1. To identify job opportunities in the space industry
2. To apply decision-making skills in small groups
3. To discuss the interdependence of personnel in completing a project

1. Introduce the concept of jobs by displaying pictures of a Shuttle, Space Station, or satellite. Have students list the kinds of jobs it takes to design, build, operate, and maintain a Shuttle, Space Station, or satellite. Discuss a misconception that the only space-related jobs are for astronauts. Divide the students into small groups to list as many jobs as they can think of under each category. Have each group appoint a recorder.
2. Copy each job onto an index card. On the bottom of the card, identify the job according to one of the four categories and have each student select a card to research.
3. Have students make oral, first-person reports on the jobs, including the job qualifications and training.
4. Divide students into groups according to their job category on the spacecraft. Give each group an assignment that will require cooperation and interdependence. The assignment could be to design, to build, to launch and operate the craft, and to maintain it before and after launch. Note that groups will have to choose leaders and individuals to meet with other groups to keep the groups coordinated. Assign two students to observe the activities of all four groups and to comment on the following:
   - How the students made decisions within their own groups
   - How the groups communicated with other groups
   - Whether the completed plans and work reflected cooperation and organization
   - Whether individuals performed the work required by their assigned jobs

   The groups should keep written records of their ideas and decisions, list assignments on chart paper, and sketch plans and designs to be displayed and shared.
5. Have each group present its work to the entire class. Ask the two student observers to present their comments and to accept explanations and rebuttals from the groups. Have students prepare oral or written statements on the following topics:
   - The importance of any job in completing tasks
   - How decisions are made in completing a task
   - How individual workers perform their jobs with others as they try to complete a task



Tracking and Data Relay Satellite (TDRS)
(see page 11)

Concept: The space program has had both benefits and costs for Earth's inhabitants.

● Give some examples of recent spinoffs of the space program, including microminiaturization of electronics, lightweight materials, solar panels, computerized scanning medical devices, portable x-ray machines, automatic utility meter reading devices, compact water filters, automatic inventory cash registers, high intensity lights, water-cooled headbands, fabrics made of strong chemical bonds, and microcomputer software. Have students research their own list. Have teams of students report on an item, whether the work it does was possible before its space application, and how the work it does changes lifestyles on Earth. Have the students illustrate their reports.

Have students pursue spinoff technologies in more detail. Teachers can locate materials through NASA Teacher Resource Centers.

a. Assign a group of students to develop a catalog of spinoff products.

b. Have students locate information on specific products and report how they are linked to the space program, e.g., fabric used for the Pontiac (Detroit) Silverdome, heat absorbing clothes for athletes, NASTRAN computer structural analysis program, and plastic welding.

c. Challenge students to create a "Technological/Economic Impact" statement highlighting and analyzing the impact of spinoffs. This could be reported in traditional oral or written formats or as a video news report format. Challenge a second group of students to create the opposite scenario, "What If We Had Not Pursued the Space Program" and to report it in a "Point-Counterpoint" format.

Although the spinoffs seem to have improved life on Earth, some individuals and groups believe that the technology has also brought increased costs. Do a cost-benefit analysis and debate the issue.

● Weather satellites are another benefit of space technology. Students may wish to research and report the following areas: forecasting, television reporting, the meteorological satellite system, economic impacts of weather satellites, and the potential issue of controlling the weather. Students could prepare video news reports or "white papers" on controversial aspects of the topic.

Present a hypothetical situation in which you are NASA and want to hire a contractor—four students—to manufacture certain parts for the Space Shuttle. Give the four students a sum of play money and a period of time to "manufacture" some meal packs for the Shuttle. Then have them dispose of their money in the economic community—the rest of the class. Use this activity to lead into the concept of circular flow of goods and services. Have students generalize about the impact of NASA spending.

● Many of the economic impacts of NASA are first felt on a local level. The areas surrounding the Johnson Space Center in Texas and the Kennedy Space Center in Florida are obvious examples. Students may want to generalize about the potential impact of a NASA facility on a community, discussing increased retail sales, employment, increased per capita income, and accelerated road and building construction.

Have students speculate about the future economic impact of space travel and colonization. They may want to use a decision-making model to decide a hypothetical issue, such as whether a space colony should be established. The key concept would be the economic impact of the colony.

● Offer the following research opportunity: In past decades, "urban renewal" has been a highly controversial topic. The current trend of "revitalization," a mix of refurbished and new construction, is a parallel. Direct students to locate information on the impacts of this trend and to compare it with renewal. Discuss the implications for life in space.

Challenge students to investigate the regulation of communications satellites (orbits and relay frequencies). They may approach it in an international economic or legal context at the present time or at some future age.

● Although the Shuttle itself is reusable, the equipment and items for crew life aboard the Shuttle may be disposable. Have students list items used aboard the Shuttle and indicate whether they are reusable or disposable. Discuss the difference between the terms "reusable" and "recyclable." Have students determine whether any disposable items could be recycled and discuss the feasibility of such an idea.

Discuss advantages and disadvantages of robotics in space and on Earth.

● The TDRSS (Tracking and Data Relay Satellite System) is an example of the potential benefits of the current flight. Mission 51-L will deploy TDRS-B, the second of three communication satellites that will allow almost full-time coverage of the Shuttle and up to 26 other satellites. Present several scenarios that involve communications satellites such as an important news story breaking in Europe, a long-lost relative calling from Latvia, or worldwide viewing of the Olympic games. Discuss how communications satellites are involved in each example and how the quality, speed, and reliability of the communications would be affected without the use of satellites.

Have students address the questions that follow in small groups, debates, written essays, or discussions.

a. Why were previous spacecraft not designed to be reusable? (technological limitations, changes in budgetary policies, and cost increases)

b. What advantages are provided by this Space Shuttle design? (more economical in terms of dollars per payload, resource conservation, ability to repair inoperable satellites, two-way transportation)

c. What considerations in terms of reuse are involved with the Space Station or other "permanent" space facilities? (similar economic considerations)

d. Consider products and packaging involved in your everyday life that could and should be recycled.

● Have a group of students prepare a collage of magazine pictures or a mural showing space technology at work in their community. Communities may allow these murals to be painted on or displayed in shop windows.

Concept: The space program generates experimentation in a variety of scientific fields.

● Provide students some background on the use of crystals in communications. Explain that the space program has extended the opportunities for scientists to study and grow useful crystals. Discuss the potential benefits of growing a crystal in a microgravity environment.

Ask students to defend or refute Isaac Asimov's idea: "Another kind of structure in outer space is factories. There is no reason why a good proportion of our industrial factories couldn't be placed in orbit. Pollution that it produces can be discharged into space."

Explore the following thought questions:

a. How does the process of growing a crystal of germanium or silicon differ from growing crystals of sugar or salt?

b. How would microgravity make purifying metals easier?

c. What is the advantage of containerless processing of materials over heating them in ceramic containers on Earth?

d. Why do some materials form crystals and others do not?

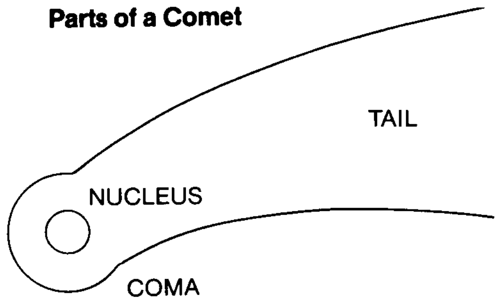
● Ask students to prepare two advertisements that would convince manufacturers to conduct experiments aboard the Shuttle. One group could do a magazine advertisement; the second, a radio or television advertisement. Generate ideas in a brainstorming session.

Objectives:

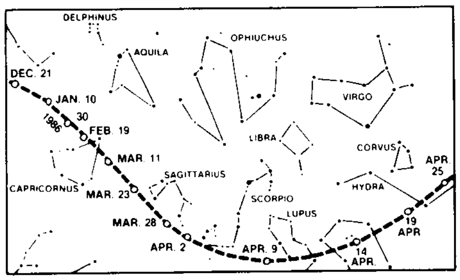
1. To describe the structure and behavior of the Comet Halley
2. To draw a comet and label its parts
3. To explain that light radiation exerts pressure
4. To place ultraviolet radiation in the electromagnetic spectrum correctly and compare its wave lengths to that of light

1. Explain to students that on Flight Day 3, the Spartan astronomical instrument was deployed from the payload bay to examine the tail of Comet Halley. At this time, radiation pressure from the Sun will make the sublimation of materials from the head of the Comet the greatest. The ultraviolet spectrometers on the Spartan will tape record Comet radiation invisible to the human eye. The Spartan unit was retrieved by the Shuttle on Flight Day 5. When returned to Earth, the data will be analyzed and compared to other ultraviolet data gathered by Spacelabs and satellites to help us understand the Universe.
2. Ask students who have recently observed Comet Halley to describe their sightings to class members. List pertinent facts on the chalkboard. Show a chart or diagram of the Comet's structure and orbit. Have students use the chart to locate the Comet's position in reference to the Sun–Earth orbit on the day of sighting.
3. Have students draw and label the parts of the Comet.
4. Have students discuss why the tail is visible only when the Comet is close to the Sun. Use dry ice to represent the Comet, a flashlight to represent the Sun's light, and a vacuum cleaner's blower-end attached to the flashlight to represent the solar pressure of light. Darken the room. Have a student circle close to the "Sun" carrying the tray of dry ice while the blower directs the sublimating gas away from the coma. Observe that the gaseous tail is always streaming away from the Sun. Question students as to which parts of the demonstration are similar to Comet Halley's trip close to the Sun. Explain that the pressure of light is due to tiny particles called photons. Light can exist in fact as both wave and particles. The pressure of our Sun's light is called the solar wind in space.
5. Exhibit a "dirty snowball" with a rock core. Explain that in the vacuum of space, ice changes to gas without melting (sublimation). The dirt becomes the dust of the tail, and the particles in the rocky core eventually disintegrate to dust. We see them as meteors in our upper atmosphere.
6. Darken the room and demonstrate one property of ultraviolet light by shining an ultraviolet (UV) light source on "glow in the dark" materials. Clap erasers near the beam of the UV source to see if eraser dust appears different under UV than in normal light. WARNING: *Do not allow students to look directly at the bulb. The light could burn the eye's retina.*
7. Show where UV radiation is located on the electromagnetic spectrum chart. It has shorter wavelengths than visible light, but not as short as x-rays. Explain that astronomers have used space-orbiting spectrometers sensitive to UV to study dust clouds, our Milky Way, and other galaxies. They want to compare the effect of our Sun's UV on Halley's dust.

Parts of a Comet



MOVEMENT OF COMET HALLEY



Late Jan. to Feb., '86	Comet at its brightest but cannot be seen from Earth as it circles the Sun.
Feb. 24, '86	Comet reappears in early morning sky, just before sunrise, a few degrees above the eastern horizon.
Mar. 6, '86	Comet visible, perhaps with a small tail, 5 degrees above the eastern horizon during dawn twilight.
Mar. 26, '86	Comet 10 degrees above southeast horizon in pre-dawn morning. Its tail may reach up to 20 degrees or more.
April 10, '86	Comet 10 degrees above southern horizon at the crack of dawn. Comet should be at its brightest.
April 11, '86	Comet begins its journey outbound.
April 12, '86	Comet visible before dawn in the southwest and after sunset in the southeast.
April 17, '86	Comet 7 degrees above the horizon after sunset in the southern sky.
Late April, '86	Comet fades from unaided vision.

Concept: The space environment is a catalyst for creative expression in art, music, and literature.

● Review with students the music that throughout history has resulted from exploration, migration, and conquest: the sea chanty, Appalachian folk songs, Negro spirituals, Western ballads. Trace the development of each from their sources to 20th-century interpretations. Then challenge students to create a comparable musical form and expression for space. Have them write a paragraph about their reasons for choosing the style, instrumentation, and lyrics.

Challenge music students to imagine that they have been named to compose the theme music for a space mission. Ask them to identify their musical style. Then ask them to identify the moment their composition would begin—launch, orbit, sleep, space walk. Next, ask them to identify the mood or feeling of a piece that best shows the kind of work they would compose. Ask them to compose a given number of measures.

● To commemorate the 50th anniversary of the National Society of Professional Engineers, Richard Bales composed *The Spirit of Engineering* for orchestra. Have students consider what kind of music would capture the Spirit of Exploration, of Science, of Learning, or of Mission 51-L (chamber music, a march, a chorale).

Have students research and report on "What effect has space exploration had on music?" including a discussion of improved recording techniques as a function of advanced electronic technology and the use of electronics in music composition and performance.

● Read the story of Gian Carlo Menotti's opera, *Help, Help, The Globolinks!*, to students and discuss with them the qualities that make it a space-age opera. High school students might consult with a local opera association about producing it.

Challenge students to agree or disagree with novelist James Michener's comments at a NASA symposium on "Why Man Explores." "I have always believed that an event has not happened until it has passed through the mind of a creative artist able to explain its significance." Have them put their ideas into a piece of persuasive composition.

● After discussing the modules of a space station, have students draw their own concepts and develop their ideas from preliminary sketches to detailed drawings to finished paintings or prints.

Have students depict a Space Station in different pictorial styles (e.g., realism, expressionism, abstract). Have them paint two views: (1) the Space Station seen from the Shuttle and (2) the view from the Space Station. Then have them select one of the compositions to explore a variety of techniques—water color, oil, tempera, and collage.

● Have teams of five to eight (the numbers of the Shuttle crew) students draw cross sections of the interior of the middeck area of the Space Shuttle. Challenge each team to choose a color and decorating motif to use in their drawing. The interior of the Shuttle orbiter is white. Discuss color likes/dislikes of individuals, and how various colors affect moods and sense of space. Have the students compare the colors of their classroom, the cafeteria, gymnasium, and a room at home and discuss the reasons why specific colors are selected. Have each student describe his/her personal preference for the interior design of the orbiter and then, what modifications might have to be made to accommodate the tastes of other crew members.

Discuss how artists interpret their awareness of the world: some paint directly from nature, some from experience and memory, some from sketches of nature, and some from imagination. Have students think about how an artist would work during a spaceflight.

● Read poems that mention heavenly bodies, aerospace personalities, and space objects—from nursery rhymes to modern poets—and compare fanciful literature with fact.

Read Gore Vidal's Visit to a Small Planet *and discuss how the alien visitor is like/unlike Earthlings. Read Edmond Rostand's* Cyrano de Bergerac—*are any of the means of spaceflight devised by Cyrano plausible?*

● Talk with students about science fiction authors—Isaac Asimov, C.S. Lewis, Jules Verne, H.G. Wells, Arthur C. Clarke. Read passages from some of their works and assign their books for reports. Discuss with students whether any of the ideas predicted by the authors already may have come to pass.

Astronaut Jeff Hoffman is an astronomer. Ask students to listen to his description of space and to discuss his word choice and sequence of details which enrich his narration. "The sight of the ice particles in front of the Shuttle is like...fireflies...They're different colors. Some of those sparkles out there are red...most of them are white ...some really bright ones out there....And as the Sun sets on the orbiter, the ice crystals go out. The last few of them turn red. Then they're red. Then they're gone." Later he says, "When you look outside and see the black of space and the ice crystals following us around and the sunrise and sunset every hour and a half, look out and see the lightning storms flashing, the cities making their light patterns beneath the clouds, the patterns in the ocean, flying over the Himalayas as we do the last two orbits tonight, then I know I'm really in space."

RECORDING THE SPACE EXPERIENCE

Concept: The space program engenders diverse reports, stories, and other forms of communication.

● Have students role-play a news correspondent assigned to cover the flight of the Teacher in Space. Ask them to write the news story and a feature story based upon one phase of the event.

Astronaut Jeff Hoffman kept an audio diary of his April 1985 mission. Discuss how this is an example of oral history. Talk with students about the function of oral history. Order a copy of his tape from the National Public Radio Catalog. (See Resources.) After listening to it, discuss if it is more moving to hear rather than to read his words.

● Oral communication is a vital function of the space effort. Have your students help you make a flow chart of the kinds of roles and functions of oral communications during the launch, orbiting, and reentry of the Shuttle. Help them to understand that for each speaking role, there is also a listening role.

Brainstorm the ways in which communication skills of reading, writing, listening, and speaking are used in training for and during a mission.

● McAuliffe is keeping a journal of her experiences. List individuals in history who have kept diaries. Discuss why diaries have been important to later generations.

The second Space Flight Participant will be a journalist. Have students consider the reasons why one of the writing professions was selected and what other writers might like to make a Shuttle flight (poets, science fiction authors). Ask students what other communications professions will probably be represented in the Space Flight Participant Program and list them in order of importance.

● The Mission launch and its ongoing coverage expose students to the jargon of space. With your students, begin to make a list of all terms which have been "coined" by the space program. Place each term or acronym with its definition on a file card. Begin to post them around the room, adding new ones in alphabetical order.

As Mission 51-L progresses, have students collect all news articles, pictures, and any other graphic details which they find. At the conclusion of the Mission, make a class collage, emphasizing the details which the class votes most significant.

● Ask each student to choose a favorite part of the mission which was shown on the live lesson. Allow the student to choose his/her best way of communicating information about that part: oral report, written paragraph, news report, dramatization, role playing, etc.

Identify key events in the history of spaceflight and express them in a workable chronology. Speculate about future events in space.

● Use Comet Halley as a springboard for historical investigation. The reference dates for its returns are 1652, 1758, 1835–1836, 1910, 1986, and 2062. Key question: What has life been like during past returns of Comet Halley? What do you think life might be like during the next appearance in 2062?

Possible projects:

***a.** Time capsule approach. Have students create a time capsule that depicts life in the United States in 1986. Have them compare the contents of their capsule with the expected contents of other reference years using inventory lists of facsimile artifacts.*

***b.** Time frame approach. Have students imagine that a video is being made entitled "History of the World, Part I." It will include everything from the beginning until now. Their task is to prepare — either visually, orally, in writing, in skits, or in video-vignettes — the frames or scenes from those reference years in which Comet Halley was present. Themes in their time frames can include styles, housing, technology, food and agriculture, currency, manufacturing, important people and events, types of governments, medical science, social and economic conditions, music, dance, and entertainment.*

● Discuss the relationship of the following events to historical themes:

a. Do you think there is a space race? Why and how did it develop?

b. What other themes and events paralleled the space race?

c. What social themes are linked to space history?

d. What evidence is there that international competition was replaced by cooperation?

e. How have economic themes affected the space activities?

Objectives:

1. To write articles that can be submitted to a student newspaper

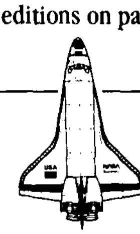
2. To publish a student newspaper about space and the Teacher in Space

1. Technological improvements in satellite communication have enabled publishers to print newspapers with national appeal. Television and radio news receive and send their messages via satellite and microwaves, enabling us to follow news-making events. The Teacher in Space project will be no exception. While the commercial media carry the event, students can track the mission from their own perspective, in their own newspaper.
2. Distribute current newspapers to groups of students. Discuss the functions of different kinds of stories and help the students identify the parts of the newspaper: news articles, features, editorials, comics, and advertisements, etc. How might newspapers be similar or different in the future?

   a. Identify information about Mission 51-L which would make a good news or feature story. Divide the class into small groups to write news stories.

   b. Discuss Mission 51-L. List the kinds of products which could be the subject of advertisements. Ask students to divide into groups. Have each group select a product to advertise in the newspaper, e.g., a space suit, a space meal, or a trip. Challenge each group to design an advertisement for the newspaper, complete with illustration, prices, and details likely to attract sales.

   c. Divide the class into three groups to express their opinions on the Teacher in Space project. One group will write editorials, one the letters to the editor, and the third the cartoon.
3. Using the students' articles, publish a class or school newspaper which records events about Mission 51-L and space in general.
4. To complement the student-produced newspaper on the present mission, challenge students to prepare editions on past and future space missions.



Concept: As humanity's presence in space grows, so does the future need for laws and decision making.

● List potential problems of law and governance in space: rights of space travelers, repatriation of downed astronauts, liability problems, ownership or control of heavenly bodies or areas. Investigate the current status of law in space. To introduce the topic, present the following problem:

> Geosynchronous satellites orbit above Earth. Who determines right of way for these orbits and who assigns transmission frequencies? (The United Nations. The International Telegraph Union, ITU, has a special arm, the World Administrative Radio Conference, WARC, to make such allocations.)

Assign students to research the network of U.N. and intergovernmental space agencies which establish and enforce space laws.

Have students research existing guidelines and principles for space government. Provide copies of the provisions of the Treaty on Principles Governing the Activities of States in the Exploration of Outer Space, Including the Moon and Other Celestial Bodies *opened for signature by the U.N. General Assembly in 1967. Discuss with students why it is called the Magna Charta for space.* *(See Illustration below.)*

● Give specific examples of circumstances that the students could classify by the appropriate treaty provision. For example, "A country cannot claim territory in space." "A country should regulate the space activities of its citizens." (See Illustration below.)

Encourage students to create editorial cartoons or vignettes involving the special problems of space law.

● Have students design an outer space regime as they believe it should function. The Star Trek Federation is a good hypothetical example. Some issues surrounding the creation of the regime may be one nation–one vote versus votes based on contribution, enforcement, jurisdiction, and courts.

> *"Tonight I am directing NASA to develop a permanently manned space station— and to do it within a decade."*
>
> *—Ronald Reagan, State of the Union Address, January 25, 1984*

Ask students why the President made that decision, committing vast amounts of national resources at a time when budget deficits were rising.

Introduce the concept of a decision-making model or process. Use examples of other pivotal space decisions, such as the lunar landing, or ask students for their ideas of other historical decisions. Reinforce the concepts of goals, alternatives, and expected outcomes.

● Use the Spaceship Decision-Making Model (See Illustration p. 4.) to "walk through" the Space Station decision with the class. Apply the Model to a variety of space-oriented problems. Historical decisions may be researched and evaluated in terms of "accuracy." Present decisions may be followed closely, while future decisions may be considered. These may be done individually, in small groups, or as a whole class.

a. Historical Decisions
   1) Creation of NASA
   2) Kennedy's goal of reaching the Moon before 1970
   3) Participation of other countries in early space efforts
   4) Continuation of Apollo after 1967 deaths
   5) Inclusion of women as astronauts
   6) Apollo/Soyuz joint mission
b. Current Decisions
   1) Sharing scientific data with other nations
   2) Use of Earth observation satellite data by governments
   3) Cost factors
   4) Manned vs unmanned space missions
c. Future Decisions
   1) Space colonization
   2) Space manufacturing or mining facilities
   3) International space ventures
   4) Landing on other planets

A Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies. The Treaty was opened for signature on January 27, 1967. This "Outer Space Treaty" or "Space Charter" has been characterized by some as a Magna Charta for space. Treaty provisions declare that:

(1) International law and the Charter of the United Nations shall apply to space activities.

(2) Outer space and celestial bodies are the province of mankind and shall be used only for peaceful purposes and for the benefit of all mankind.

(3) Nuclear weapons, weapons of mass destruction, military bases, and military maneuvers are banned from space.

(4) Outer space shall be free for exploration, use, and scientific investigation.

(5) There can be no claims of sovereignty or territory by nations over locations in space, "by means of use or occupation or by any other means."

(6) Jurisdiction over space objects launched from Earth shall be retained by the launching state.

(7) Private interests are recognized as having freedom of action in space, so long as a government or group of governments on Earth authorize and exercise continuing supervision over their activities. Signatory nations (seventy-eight at last count, including the United States and the Soviet Union) are therefore under a duty to oversee the activities of their citizens and commercial ventures in space.

(8) Governments are liable for damage caused on Earth by their space objects.

(9) Astronauts are "Envoys of Mankind" and are entitled to noninterference and all necessary assistance in distress.

(10) The natural environments of celestial bodies should not be seriously disrupted, and Earth must not be contaminated by extraterrestrial organisms.

NASA Teacher Resource Centers

Teacher Resource Centers at major NASA installations provide easy access to NASA-related materials that can be incorporated into the classroom at all levels. The materials reflect NASA research, technology and development in a variety of curriculum and subject areas. Resources available include NASA videotapes, 16mm films, 35mm slides, NASA publications, audio cassettes, computer software, laser discs, teacher's guides, and classroom activities. Educators can review the material and request copies for use in their classrooms. The only charge is the cost of reproduction and mailing. Visit or contact the Teacher Resource Center nearest you for information about services and materials:

ALABAMA SPACE AND ROCKET CENTER
Attn: NASA Teacher Resource Room
Tranquility Base
Huntsville, AL 35807
(205) 837-3400, Ext. 36

NASA AMES RESEARCH CENTER
Attn: Teacher Resource Center
Mail Stop 204-7
Moffett Field, CA 94035
(415) 694-6077

NASA GODDARD SPACE FLIGHT CENTER
Attn: Teacher Resource Laboratory
Mail Stop 130-3
Greenbelt, MD 20771
(301) 344-8981

NASA JET PROPULSION LABORATORY
Attn: Gil Yanow
Science and Mathematics Teaching Resource Center
Mail Stop 180-205
Pasadena, CA 91109
(818) 354-6916

NASA LYNDON B. JOHNSON SPACE CENTER
Attn: Teacher Resource Room
Mail Stop AP4
Houston, TX 77058
(713) 483-3455 or 4433

NASA JOHN F. KENNEDY SPACE CENTER
Attn: Educators Resource Library
Mail Stop ERL
Kennedy Space Center, FL 32899
(305) 867-4090 or 9383

NASA LANGLEY RESEARCH CENTER
Attn: Langley Teacher Resource Center
Mail Stop 146
Hampton, VA 23665-5225
(804) 865-4468

NASA LEWIS RESEARCH CENTER
Attn: Teacher Resource Room
Mail Stop 8-1
Cleveland, OH 44135
(216) 267-1187

NASA NATIONAL SPACE TECHNOLOGY LABORATORIES
Attn: Teacher Resource Center
Building 1200
National Space Technology Laboratories, MS 39529
(601) 688-3338

NASA Regional Teacher Resource Rooms have been established at the following institutions:

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U.S. Space Foundation
P.O. Box 1838
Colorado Springs, CO 80901
(303) 550-1000

Mr. Barry Van Deman
Museum of Science & Industry
57th Street and Lakeshore Drive
Chicago, IL 60637
(312) 684-1414, Ext. 432

Dr. Kenneth Pool
School of Education
University of Evansville
1800 Lincoln Avenue
Evansville, IN 47714
(812) 479-2766

Mr. Scott Seaman
Director, Learning Resources Division
Northern Michigan University
Marquette, MI 49855
(906) 227-1300

Ms. Carolyn Cooper
Olson Library Media Center
Northern Michigan University
Marquette, MI 49855
(for materials only)
(906) 227-2117

Professor David Housel
O'Dowd Hall, Room 115
Oakland University
Rochester, MI 48063
(313) 370-3079

Dr. Richard Mitchell
Curriculum and Instruction
Box 52
Mankato State University
Mankato, MN 56001
(507) 389-1516

Professor Doreen Keable
Center for Information Media
St. Cloud State University
St. Cloud, MN 56301
(612) 255-2062

Dr. Martin Marin
The City College
NAC 5/208
Convent Avenue at 138th Street
New York, NY 10031
(212) 690-6678

Dr. Paul A. McWilliams
Executive Director
NASA Industrial Applications Center
23 William Pitt Union
University of Pittsburgh
Pittsburgh, PA 15260
(412) 624-5211

Mr. Gregory L. Vogt
Executive Director
Science, Economics & Technology Center
818 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 765-9966

Dr. Ruby Koch
College of Education
213 Morris Hall
University of Wisconsin at LaCrosse
LaCrosse, WI 54601
(608) 785-8128

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