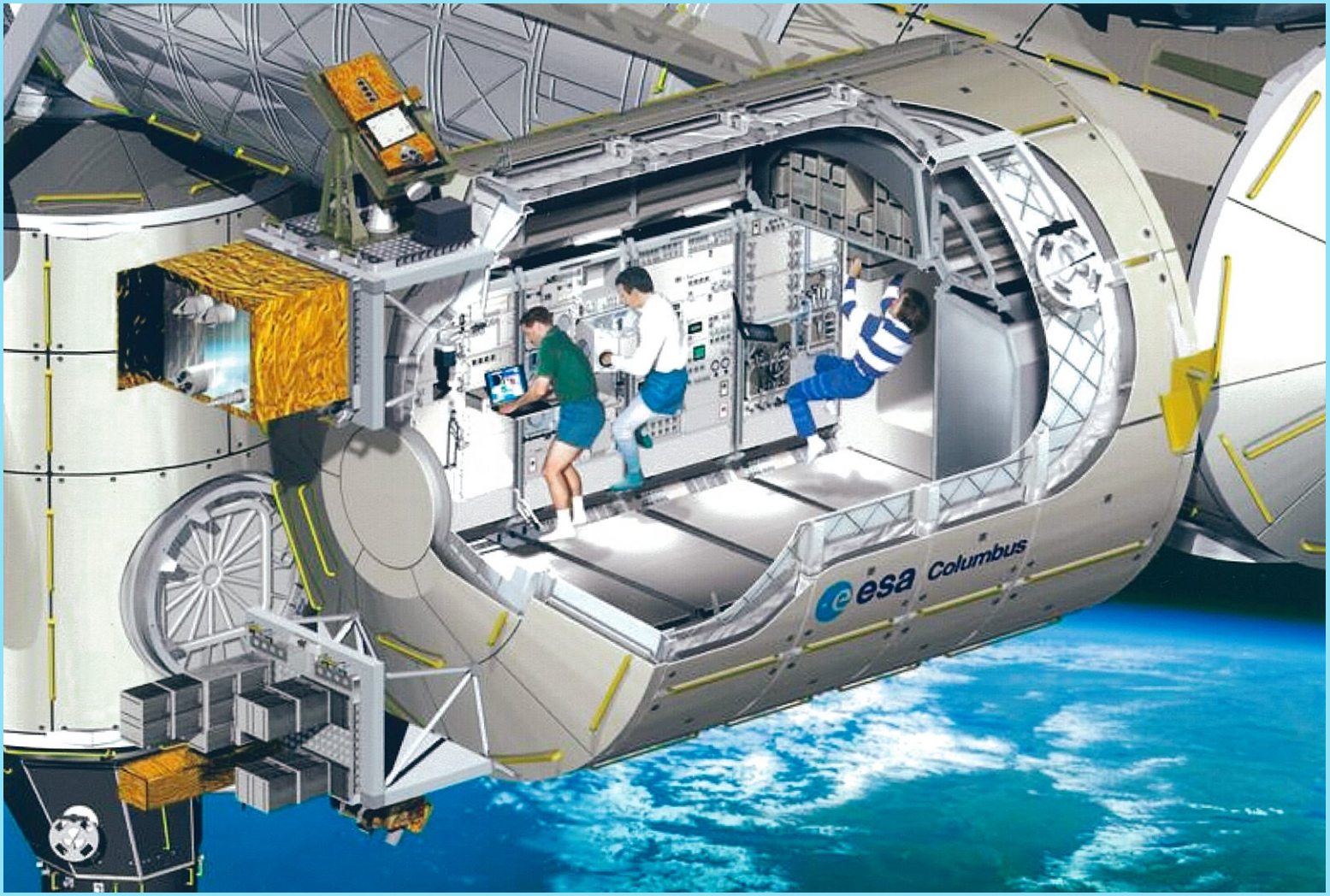
A TEACHER'S COMPANION TO THE SPACE STATION:

A Multi-disciplinary Resource



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DEDICATION

This educational work is dedicated to the awe, the wonderment, and the potential that living and working in space has to offer to generations to come.

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This work reflects National Standards and the STEM (Science/Technology/Engineering/Mathematics) Initiatives

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FOREWORD

The United States Space Station promises to be an adventure in enterprise and ingenuity. This collection of activities, geared for students from kindergarten through high school, promises to help them become aware of the potential of space. Within their lifetime, men and women will be living in space on a routine basis, carrying out activities once only dreamt of in books. With pleasure, we, the writers of this work, would like to invite you to enter the world of the Space Station. Join us as we peer through portholes and view the limitless horizons awaiting.

Lynn P. Hagan, Chairman

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INTRODUCTION

What is a Space Station? The Space Station will be an orbiting multi-purpose system of manned and unmanned elements which will grow and change in response to research requirements.

Why do we need a Space Station? Just as we moved west in the pioneering period because of our manifest destiny to settle this continent, it is our manifest destiny to explore the universe—to go there, to understand what we find, to utilize it with care.

When man went exploring, he wasn't sure exactly what he was going to find, but he knew that wanting to know and having curiosity and fulfilling that curiosity is all a part of the human condition. When we went west, all we were looking for was opportunity—the opportunity to build a better life, however we might conceive that life to be. That's exactly what we are asking now; we are asking for a future and an opportunity. For us not to go out into space and not to pursue one of the last of the frontiers left to us would be foolish indeed.

We go to space because it may well be that the best way we can build a future for ourselves "down here" is by going "out there." Developing the technology to go out there enhances the lives of us all through spinoffs. A culture which does not continue to develop begins to dissolve from within, becomes hollow, begins to feed upon the past, and has no viable future. The benefits of past space research are too numerous to list and I refer the reader to the spinoff volumes which NASA publishes each year. Whole industries and billions of dollars in benefits have come as a direct result of our space program.

We need the Space Station for the same reason that we need tomorrow and the next generation—because there is always something new to discover, to create, and to become. Socrates told us long ago that *"A man must rise above the Earth to the top of the atmosphere and beyond, for only thus will he fully understand the world in which he lives."* The only limitations that exist for mankind are those which man imposes on himself. To strive, to do, to be, to become—these are within the parameters of human behavior and endeavor. Because the human experiment begins anew with each person, so too, with each generation environmental education must begin anew. We are responsible to the future and what we do with this planet is a burden which we will bear and a debt which our children will pay.

Many of the astronauts who have gone up into space have come back as environmentalists. They tell us that seeing the planet as one cohesive whole, populated by one humanity, has taught them how important it is for us to work together to nurture and tend this garden. The Space Station will raise man's environmental consciousness to see exactly what we are doing and how we can better respond to man's needs and those of his "Spaceship Earth." The knowledge and the technological base which the Space Station will build for us will make us better and more responsible residents of this planet. T.S. Eliot once said, *"We shall not cease from exploration... (and shall) get back to where we started... and know the place for the first time."*

Kathy E. Beauford

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Primary Glossary

ELEMENTARY LEVEL

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Solar Arrays
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Trash Problems
A Trip in Space and Time
Body Climate
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SECONDARY LEVEL

What are man's physical needs and how will they be met in space?
Atmosphere
Water
Food
Shelter
Health

What are man's psychological needs and how will they be met in space?
Social
Individual

What are man's contextual needs and how will they be met in space?
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Contextual Knowledge

Man's Search for Meaning

Glossary

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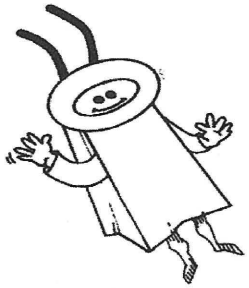
EDUCATIONAL RATIONALE

This work takes a multi-disciplinary approach to the Space Station and can be used throughout a school for a "Space Station Day" project. The disciplines treated include: English, philosophy, psychology, social studies, civics, art, music, business, physics, biology, environmental science, computer science, mathematics, chemistry, home economics, and physical education.

The lesson plans which follow are idea stimulators and suggestions and in no way are meant to supercede or replace the teacher's creativity, knowledge, and expertise. It is assumed that it is impossible in this forum to adequately design for all grade levels, and the expertise of the teacher will be required to adapt this information to a particular grade level and to the abilities of the students.

This work is not intended to be an exhaustive treatment and some sections are included as idea stimulators to flesh out the overall design and provide contextual balance.



PRIMARY

The Japanese Experiment Module (JEM)

by Lynn P. Hagan
and Liz Elsen

SPACE STATION: PRIMARY LEVEL

The Primary section introduces the students to a variety of concepts about Space via a simple lunch-bag sized puppet—Cosmic Critter. Each child will make his own Cosmic Critter as part of the first lesson. In subsequent activities, Cosmic Critter brings a variety of space related ideas to the students as they create, imitate, simulate, cut, color, and paste. These nine lessons require a minimum of materials for the teacher to supply, and should prove to be not only fun, but interesting and informative for the students.

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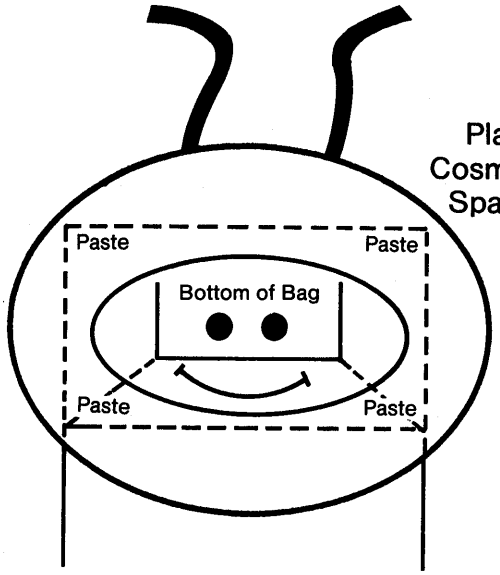
LET'S MEET COSMIC CRITTER

OBJECTIVES

Each students will make a Cosmic Critter paper bag puppet.

MATERIALS

- Critter Page A
- lunch bags (one per child and one for teacher demonstration)
- white construction paper
- light weight cardboard (used to make the helmet patterns)
- scissors
- crayons
- pencils
- glue, paste or rubber cement
- pipe cleaners



Suggested Placement of Cosmic Critter's Space Helmet

PROCEDURE

Before beginning, teacher should prepare a number of cardboard patterns.

Step 1

Have students trace and cut helmets out of white construction paper, using Critter Page A as pattern.

Step 2

Distribute bags.

Step 3

Glue helmets to bottom of lunch bags—be careful not to glue flap down.

Step 4

Give Cosmic Critter a face by drawing eyes, mouth, etc.

Step 5

Say "Hello" to Cosmic Critter!

LET'S PACK

OBJECTIVE

The students will identify items to take on a trip to the Space Station.

MATERIALS

- Critter Page "B"
- item list (next page)
- an empty child's backpack (or grocery sack)
- items provided by teacher and students

PROCEDURE

1. Have students sit in a circle on the floor.
2. Teacher has the backpack or grocery sack.
3. Each student is to tell about the item that he/she brought from home for the trip.
4. Students make the determination as to what they think is necessary for Cosmic Critter's trip into space.
5. As they decide on the necessary items, place the items in the backpack (or sack).

QUESTIONS

1. What is truly necessary for life on the Space Station? (air, food, water, etc.)
2. What items would be fun to take but would not be practical? (cars, skates, etc.)

3. Can everything go? The astronauts are not allowed to take many items into space. (not enough room)

CONCEPTS
There is a limited amount of space available on the Space Station. Excess baggage cannot be accommodated.

ITEMS FOR TEACHER TO PROVIDE
Watch, thermos of water, record or taped music, peanut butter sandwich in a zip top bag, other items at own discretion

ITEMS FOR STUDENTS TO PROVIDE (Copy and send home Critter Page "B")
Stuffed animal, tooth brush, tooth paste, story book, comb, brush, wash cloth, towel, soap, lollipops, pajamas, change of clothes, pen/pencil, crayons, coloring book, toy cars/trucks, doll, teddy bear, pair of skates, rubber ball, other items at teacher's discretion.

BLAST OFF

OBJECTIVES
The students will participate in a simulated launch of the Space Shuttle and "dock" with a simulated Space Station.

MATERIALS
- Shuttle component labels (see label page)
- string
- Cosmic Critter Puppet

PROCEDURE
1. Have 4 students represent the parts of the Space Shuttle (Solid Rocket Boosters, External Tank, Orbiter)
2. Imagine a blast-off and separation of rockets and tank.
3. The remaining students will form a configuration of the Space Station.
4. The orbiter will "dock" with the station and transfer Cosmic Critter to the Space Station.

QUESTIONS
1. What parts of the Space Shuttle are used again? (SRB's, Orbiter)
2. Was it easy to "dock" with the Space Station? (Yes, but be careful!)

CONCEPTS
Through a launch of the Space Shuttle, crews are easily transported to the Space Station as it orbits the Earth.

UP IN SPACE

OBJECTIVES
The students will be given a list of direct questions concerning the effects of micro-gravity on movement and environment. The students will attempt to answer each orally.

MATERIALS
- Critter Page "C"
- crayons
- pencils

PROCEDURE
1. Copy the Critter Page and distribute one to each student.
2. Discuss with the students the questions Cosmic Critter is asking.
3. Have the students hold a pencil in the mouth of their Cosmic Critter puppet. Drop the pencils.

QUESTIONS
1. Why is Cosmic Critter floating into the Space Station? (no gravity)
2. How will his room on the Space Station be different from his room on Earth? How will it be similar? (no furniture, but it does have windows and "bunks")
3. If Cosmic Critter dropped a pencil on the Space Station, would it fall to the ground? (no)
4. What makes the pencil fall to the ground on Earth? (gravity)

CONCEPTS
Unlike Earth, space has no gravity to hold things down.

HOME SWEET HOME

OBJECTIVE
The students will compare and contrast the living areas of the Space Station and living areas on Earth.

MATERIALS
- Critter Pages "D" and "E"
- crayons

PROCEDURE
1. Copy and distribute Critter Page to each student.
2. Discuss with the students the things which Cosmic Critter sees as he begins his stay on the Space Station.
3. After the discussion, the students may color the Critter Page.

QUESTIONS
1. What do the students think Earth might look like from the Space Station?
2. How might a bee see the Earth as it flies along? How might an ant or bird see the Earth?
3. How is the module where Cosmic Critter will be living different from the student's home (or room) on Earth? How is it similar? (see previous lesson)

CONCEPTS
In a micro-gravity environment there is no need for furniture, and most necessary equipment is of a built-in nature. Spatial limitations, as well as weight and bulk, restrict the design of many objects.

COSMIC CRITTER CREW

OBJECTIVE
The student will describe the limitations of living and working with others in a confined area.

MATERIALS
- Critter Pages "F" and "G"
- crayons
- scissors
- paste or glue

PROCEDURE
1. Copy and distribute Critter Pages.
2. Have the students cut out the Cosmic Critter Crew and paste it on Critter Page "G."
3. Discuss with the students how the first Cosmic Critter might feel in the small space with a large crew.
4. After the discussion, the students may color the Critter Page.

QUESTIONS
1. How would the students like to work and live in such a confined environment?
2. What animals on the Earth live and work in a confined area? (bees, wasps, ants, etc.)
3. Do the students feel that in such a small area there would have to be special rules and specific jobs to do to keep the Space Station functioning properly? (leader, division of jobs, scheduling)

CONCEPTS
Living in tight quarters for an extended period of time presents difficulties of physical, spatial, and psychological natures.

COSMIC CRITTER STEPS OUT

OBJECTIVE
Given a choice of coverings, the students will assemble appropriate protective covering for "space walks" and other "out of vehicle" activities.

MATERIALS
- Cosmic Critter puppet
- Critter Pages "H," "I," "J" and "K"
- scissors
- tape
- crayons

PROCEDURE
1. Copy and distribute Critter Pages.
2. Discuss with the students the need for appropriate dress while in space.
3. Allow the students to cut out the clothing they feel is the most appropriate for space.
4. Dress Cosmic Critter by taping the clothes on the puppet.
5. Use the remaining sheets to discuss the types of activities that are appropriate for the clothing.

QUESTIONS
1. What different kinds of protective coverings do plants and animals have on Earth to protect them? (hide, tough shells, spines, camouflage, etc.)
2. Can man change his covering? How? (change clothes)
3. Why must Cosmic Critter wear the spacesuit to work outside the Space Station? (breathing, pressure, heating and cooling)

CONCEPTS
Protective coverings in space, as on Earth, are essential to the survival of the living being.

SNACK TIME—TRASH TIME

OBJECTIVES
The students will experience eating a familiar food in an unfamiliar manner, i.e., simulation of tube-feeding of applesauce.
The students will consider and discuss the problems inherent in trash production and disposal.

MATERIALS
- 2 or 3 jars of applesauce
- spoon
- scissors (one pair)
- small sized zip-lock type baggies (one for every student, and one for demonstration by the teacher)
- paper towels for clean up

PROCEDURE
1. Spoon a small quantity of applesauce into each baggie. Zip it securely shut. Distribute baggies to students.
2. Discuss how this could be eaten if they were on the Space Station and didn't have spoons. (Throw-away tableware would only generate more garbage.) Suggest that they think of other ways that the applesauce could be conveyed to their mouths, guiding the discussion to the possibility of squeezing it out.
3. Cut a bottom corner off of the teacher's baggie and demonstrate.
4. Snip the corners off the student's baggies and everyone can squeeze and eat.

QUESTIONS

1. When baggies are empty, what should be done about the trash? (recycle)
2. What do we do with trash on Earth? (recycle, burn, landfill)
3. Is there a lot of room on a Space Station to store trash? (no)
4. Does Earth have unlimited places to put trash? (no)
5. What do we do with some of our trash? (recycling of cans, paper, glass...)

CONCEPTS

Because of microgravity on the Space Station, the traditional methods of preparing and eating some foods need to be modified. Liquids and dry foods simply float away. It takes two people to make a peanut butter sandwich—one to hold the jar and the lid, the other to hold the slice of bread and the knife. There is no "down" to affix or hold foods to a surface.

The disposal of trash generated in a closed environmment presents real problems in a Space Station, as well as on Earth. (Earth is also a closed environment.) Recycling reusable materials is one solution to alleviate this problem.

COSMIC CRITTER COMES HOME

OBJECTIVES

The students will recall and relate some of the specific Space Station procedures and problems evoked by the lesson.

MATERIALS

- Cosmic Critter puppets

PROCEDURE

Seat the students in a comfortable circle with their Cosmic Critters. Ask discussion questions. Each student in turn can have his/her puppet respond to these questions.

QUESTIONS

1. What do you think Cosmic Critter has learned about the Space Station? About space? About Earth?
2. How does Cosmic Critter feel about being on a Space Station—or traveling in space?
3. How would the students themselves feel about being on a Space Station or traveling in space?

CONCEPTS

Life on a Space Station will be, in many ways, quite similar to living on Earth. Basic human needs will not change. How those needs are met in an environment of microgravity and limited room may, however, be quite different from how those needs are met on Earth.

GLOSSARY

airlock
a small chamber which can be sealed and emptied of air until the pressure in the chamber equals that of space so that astronauts can enter or exit a space vehicle

environment
all things, living or non-living, which impinge upon an organism

external tank
the large brown tank which supplies fuel to the Orbiter during launch

gravity
the force which pulls all things towards the center of the Earth

Orbiter
the spacecraft portion of the Space Transportation System which is used to carry payloads and astronauts into space and return them to Earth

recycle
to use again and again

solid rocket boosters
rockets that burn solid fuel—two solid rocket boosters are used to help get the Shuttle into space

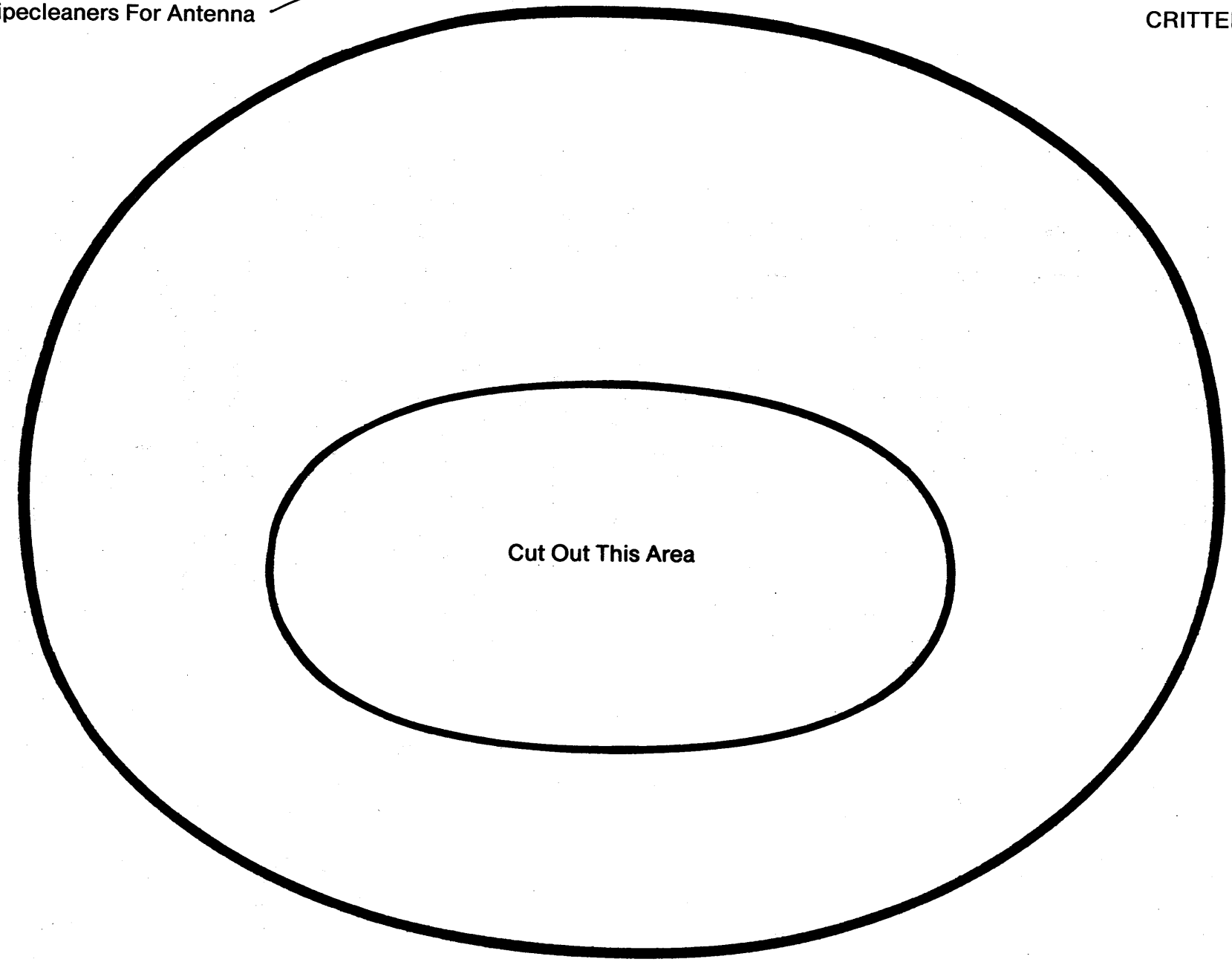
Space Station
a spacecraft which provides for the continual habitation of space by the astronauts

spacesuit
pressurized suits that astronauts use to leave the spacecraft. The suits control pressure and temperature while supplying oxygen to the astronauts, allowing them to survive outside the spacecraft for several hours.

weightlessness
word used to describe the condition in which all objects float in space

Attach Pipecleaners For Antenna

CRITTER PAGE A



CRITTER PAGE B

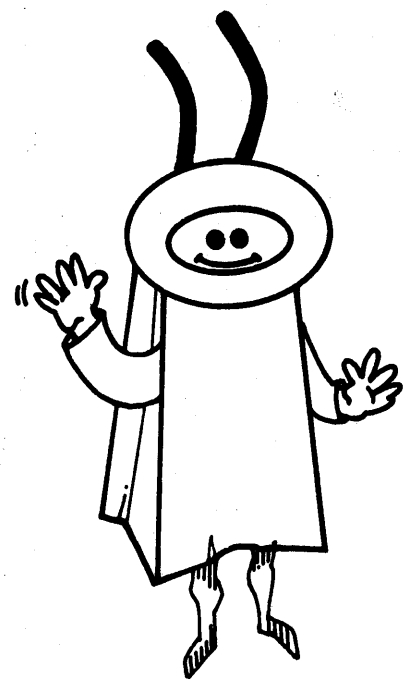
HI PARENTS!

YOUR CHILD IS HELPING ME PLAN A TRIP TO SPACE, AND NEEDS TO BRING

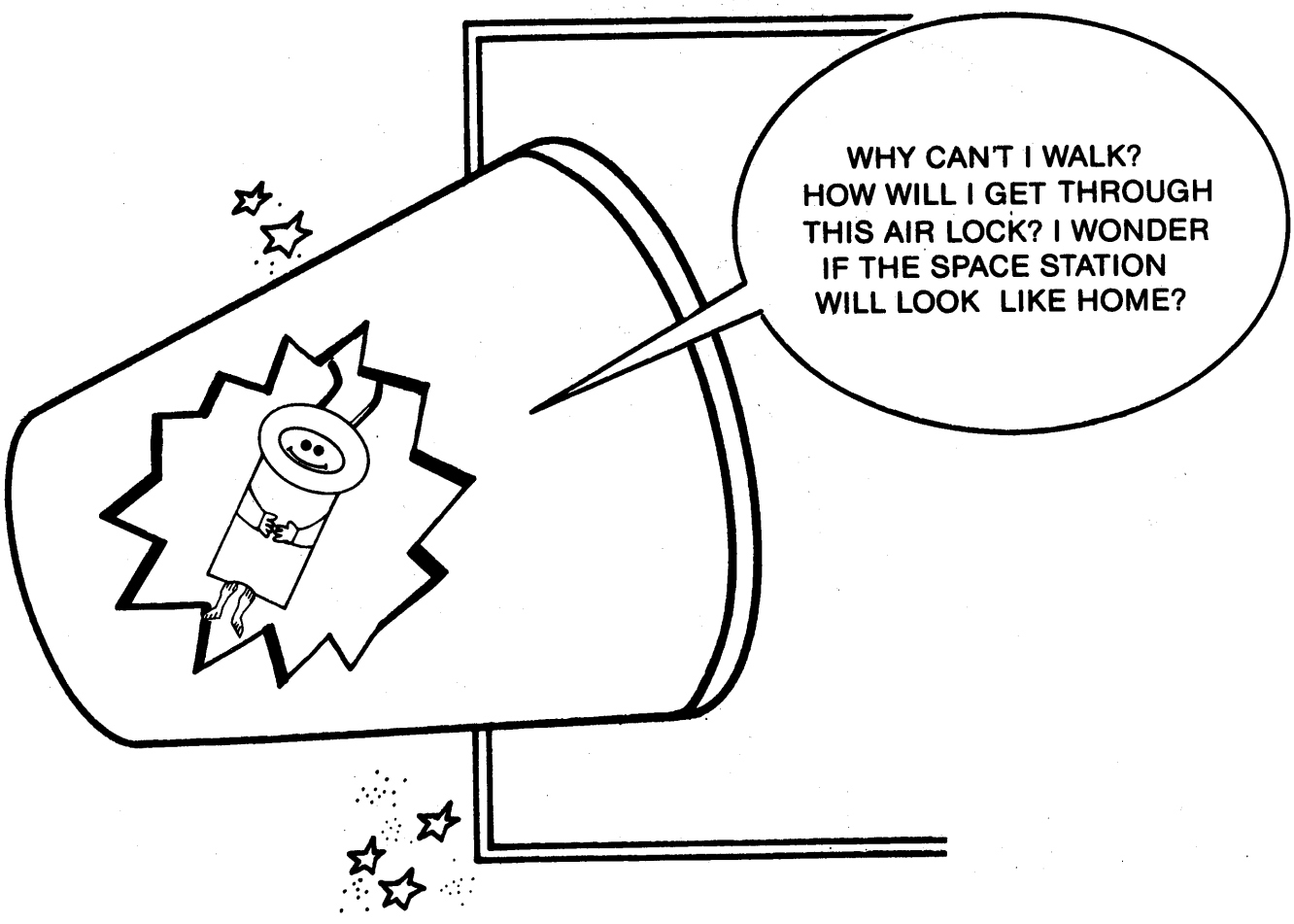
_____

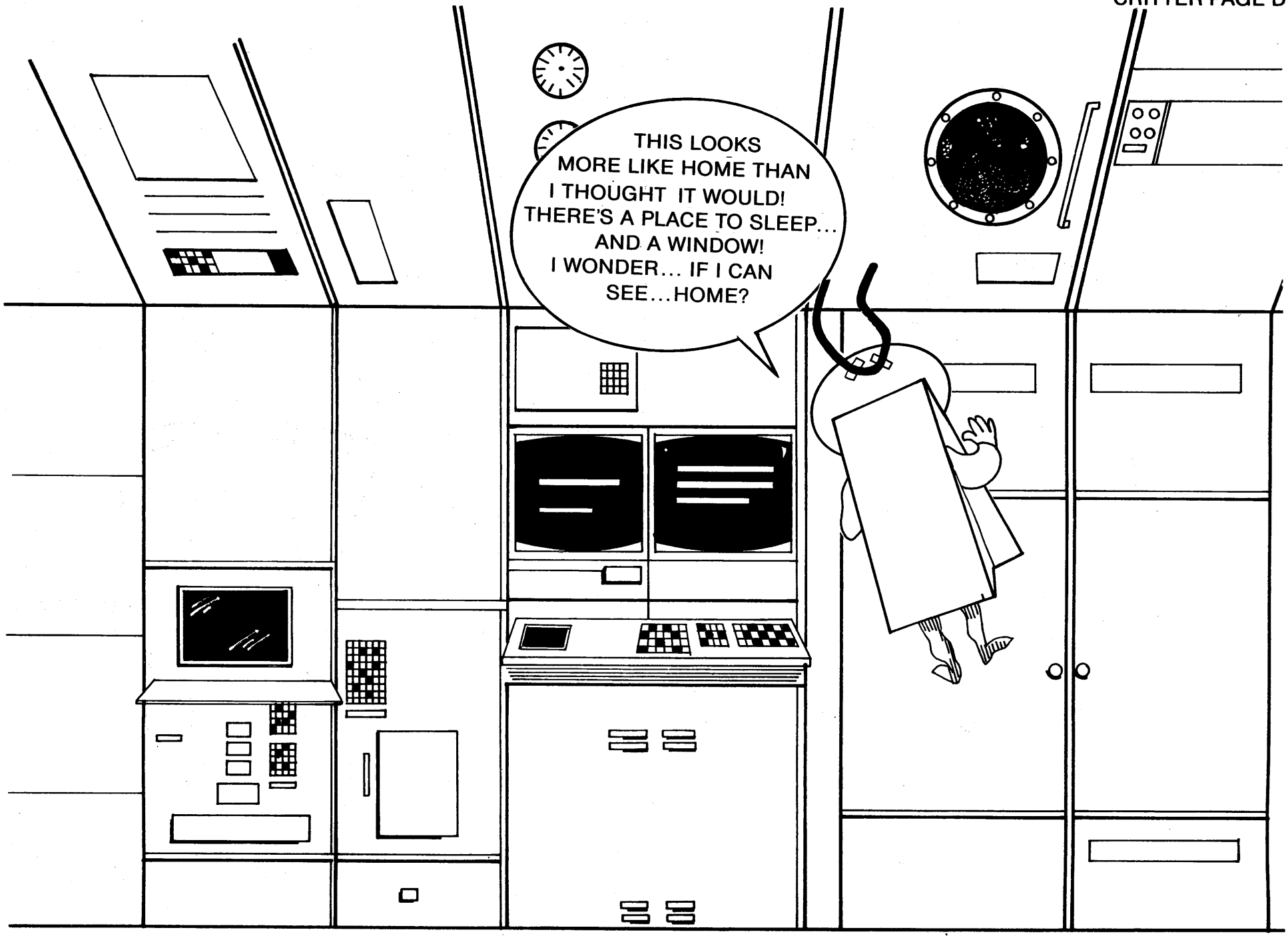
TO SCHOOL TOMORROW

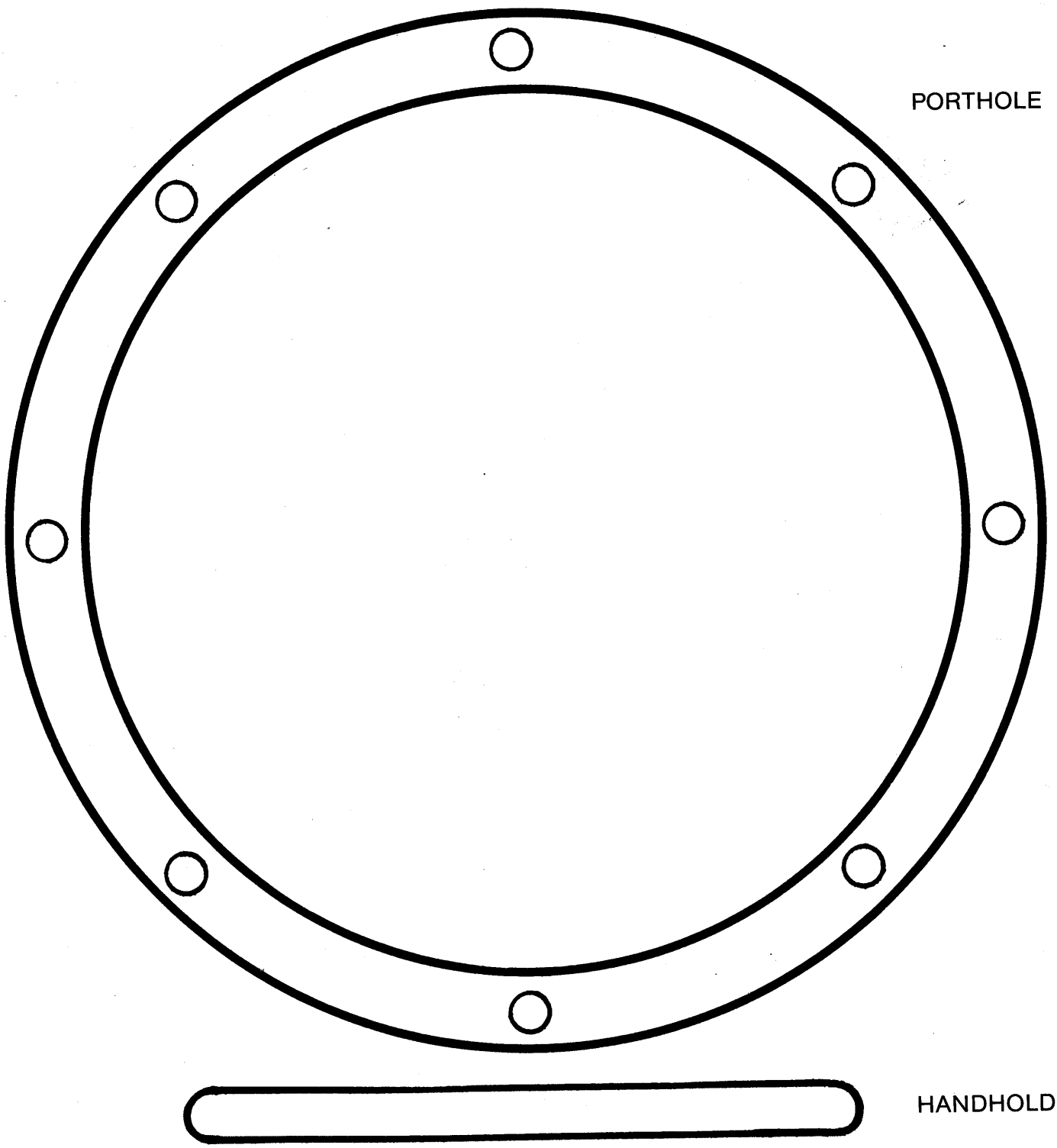
THANKS!
COSMIC CRITTER



CRITTER PAGE C



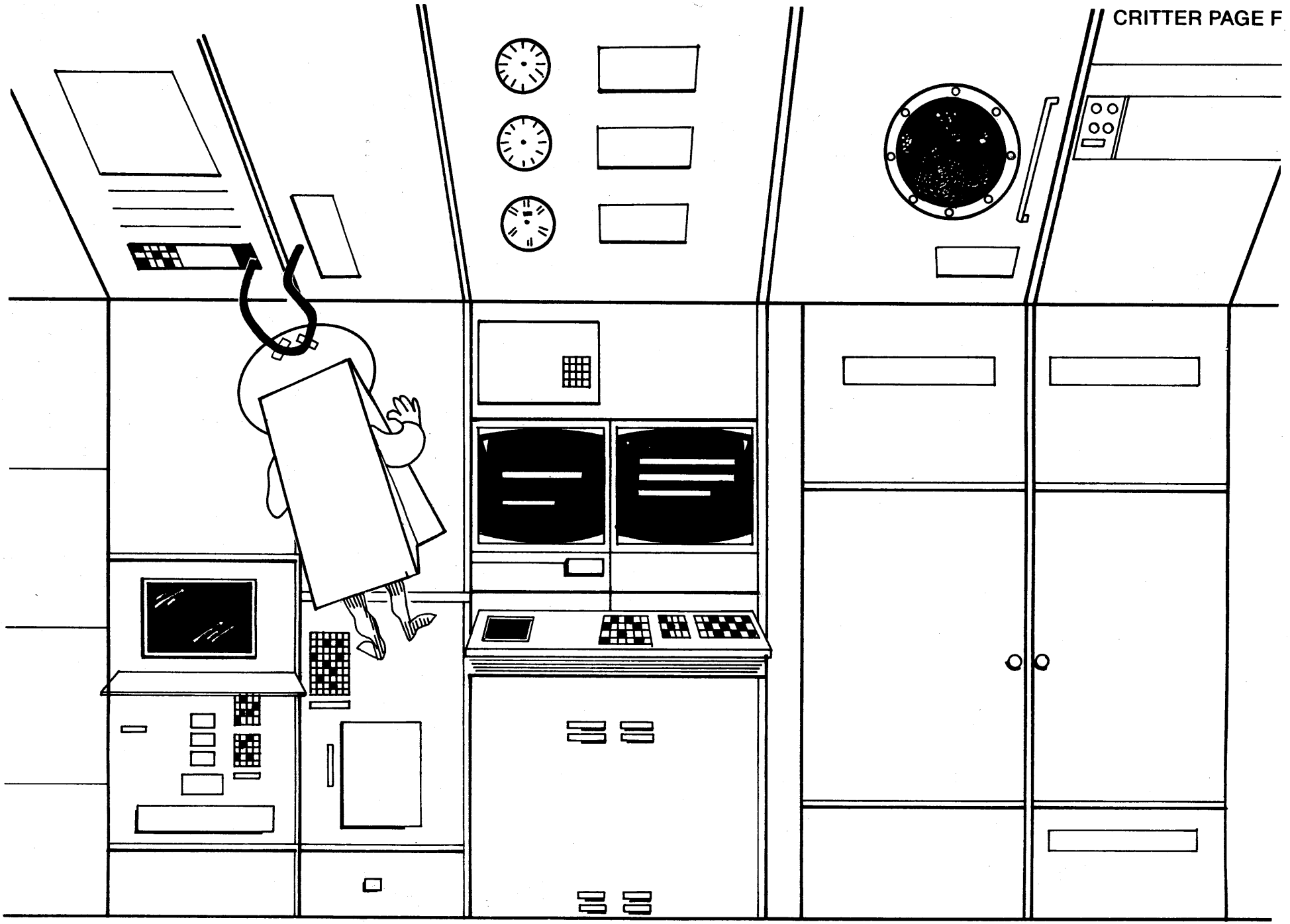

THIS LOOKS MORE LIKE HOME THAN I THOUGHT IT WOULD! THERE'S A PLACE TO SLEEP... AND A WINDOW! I WONDER... IF I CAN SEE...HOME?

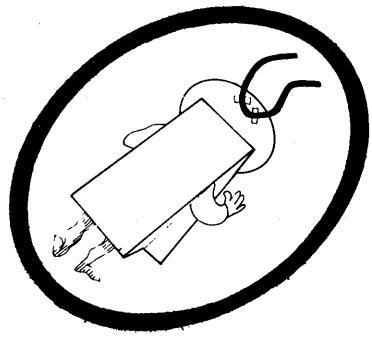


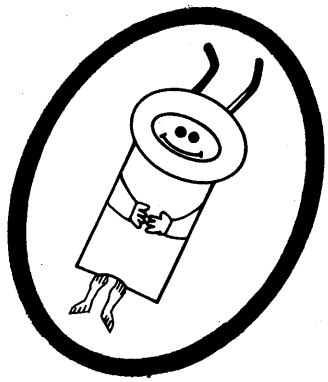
PORTHOLE

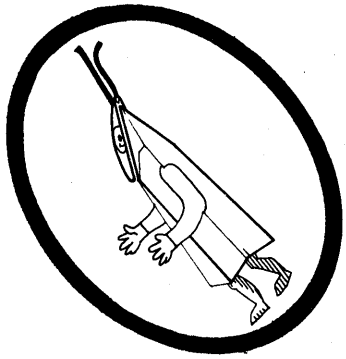
HANDHOLD

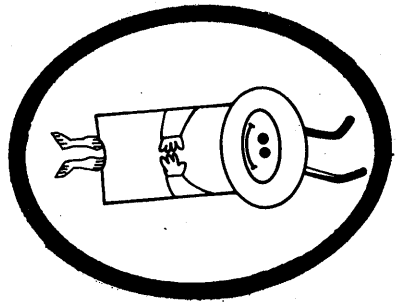
Draw What Cosmic Critter Sees When He Looks Through The Porthole.

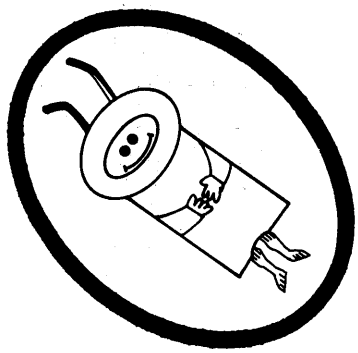


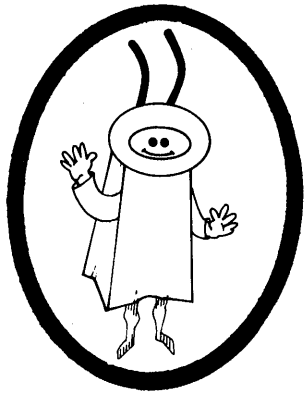


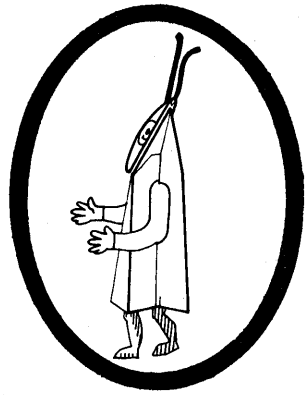




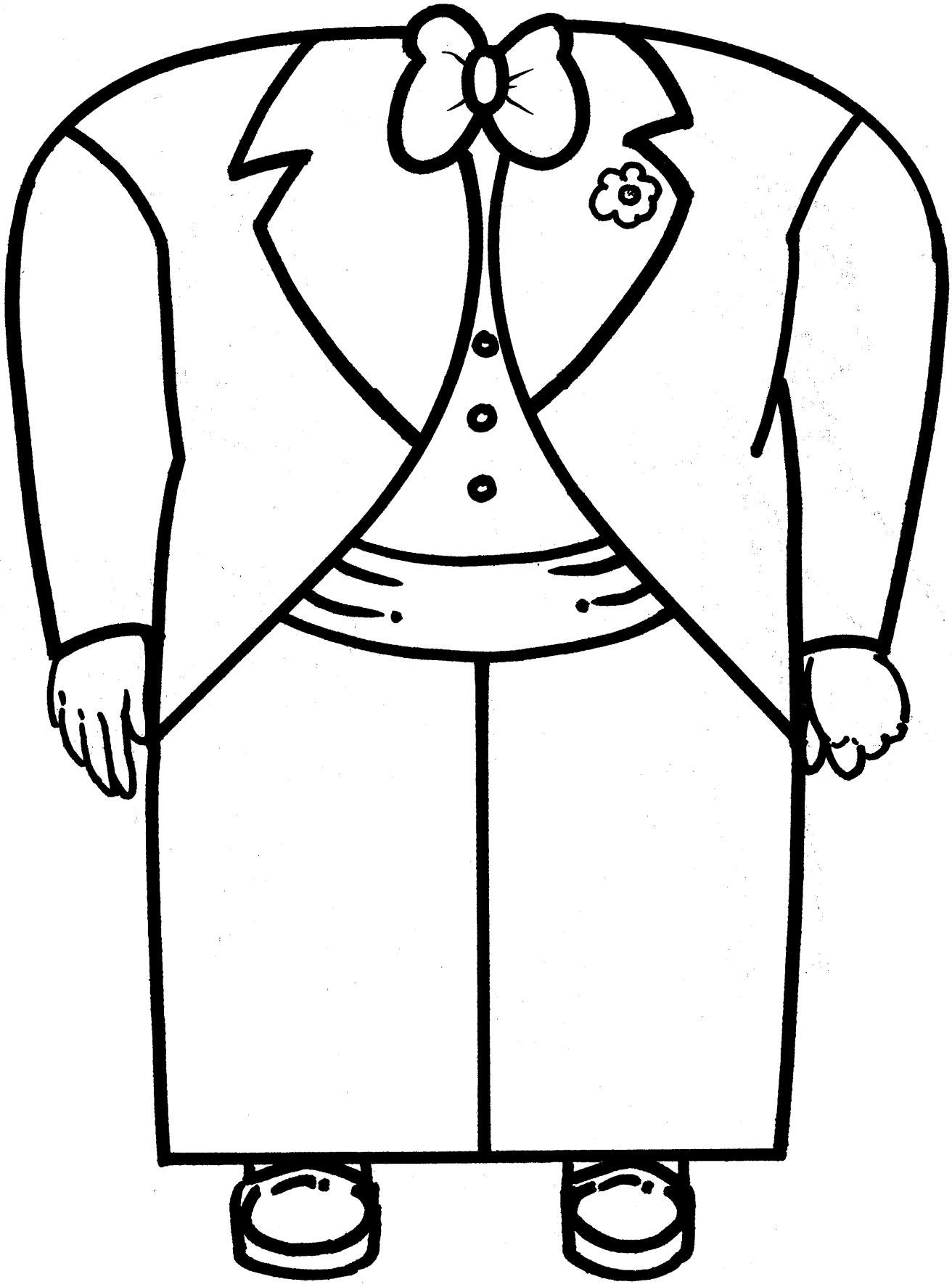








COSMIC CRITTER CREW
Cut out each Cosmic Critter Crew Member and paste onto activity sheet



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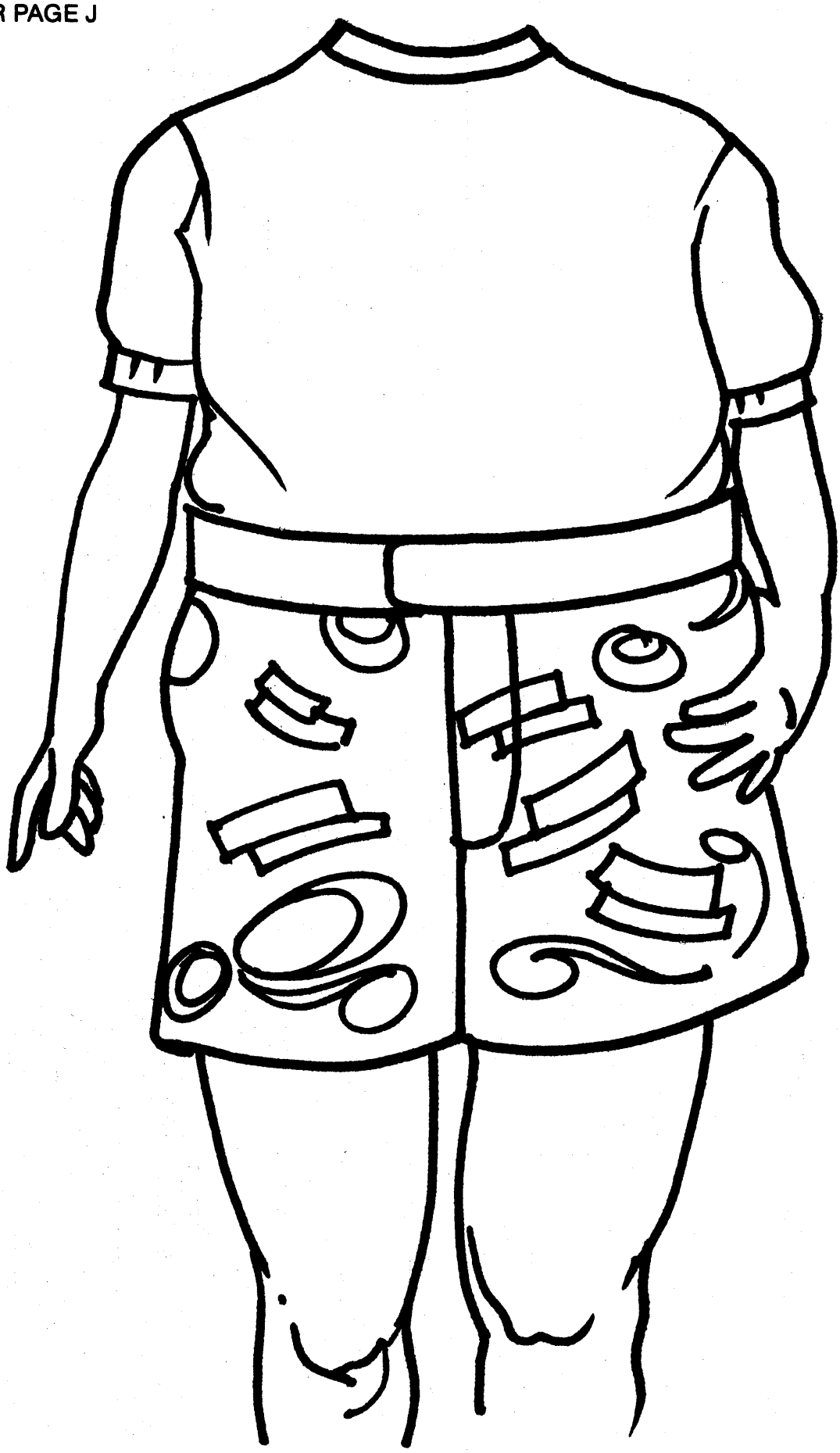

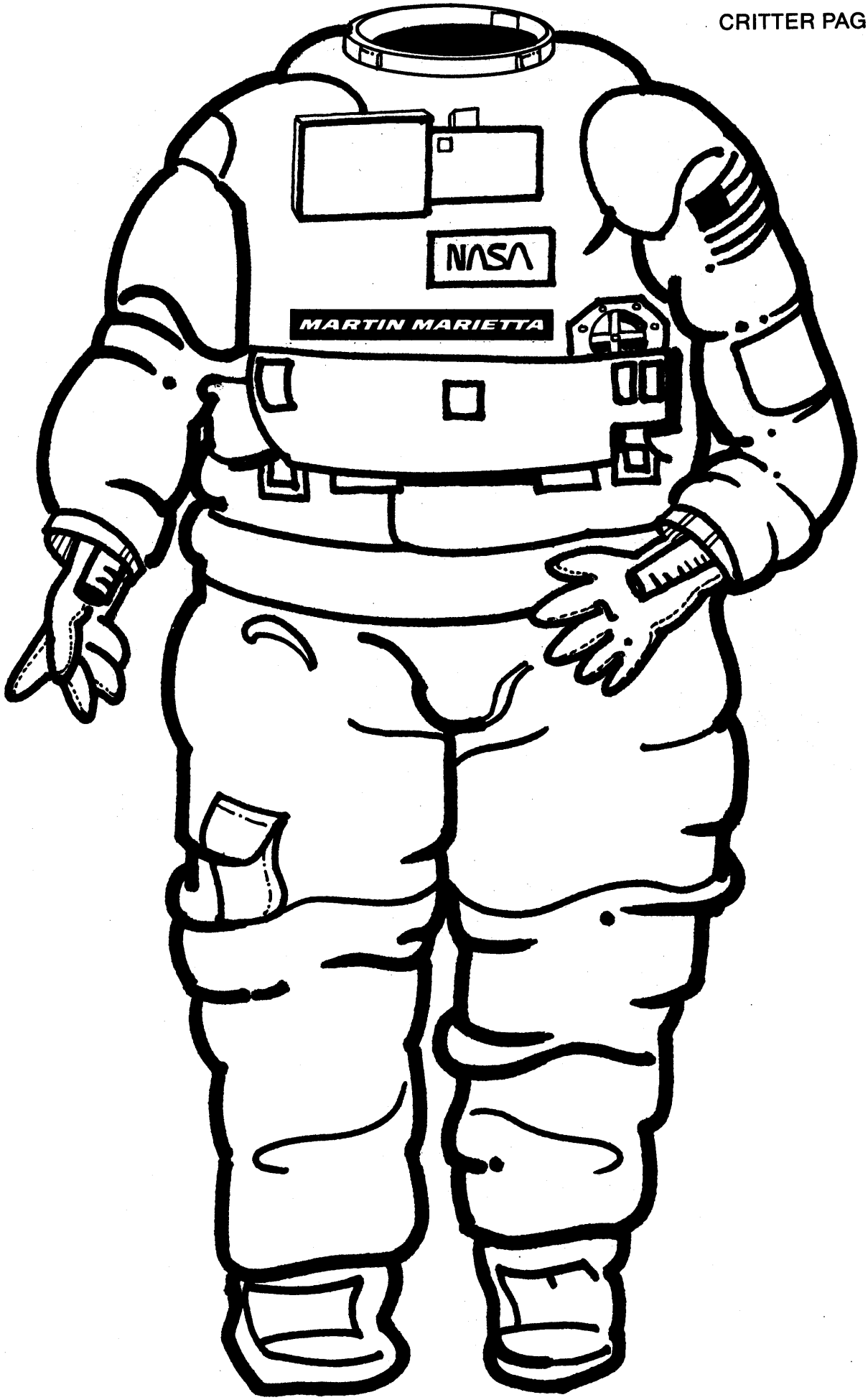
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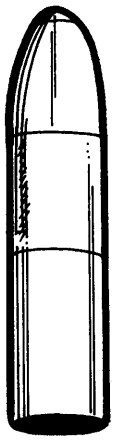

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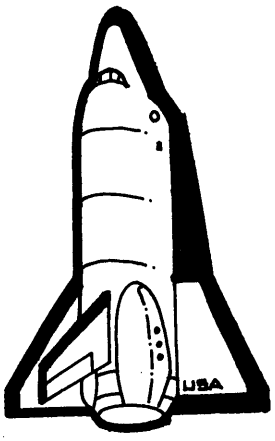
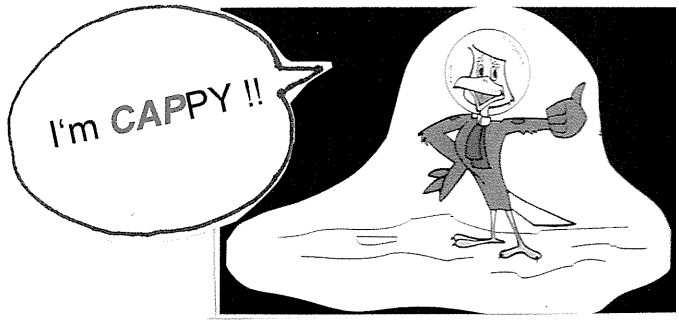
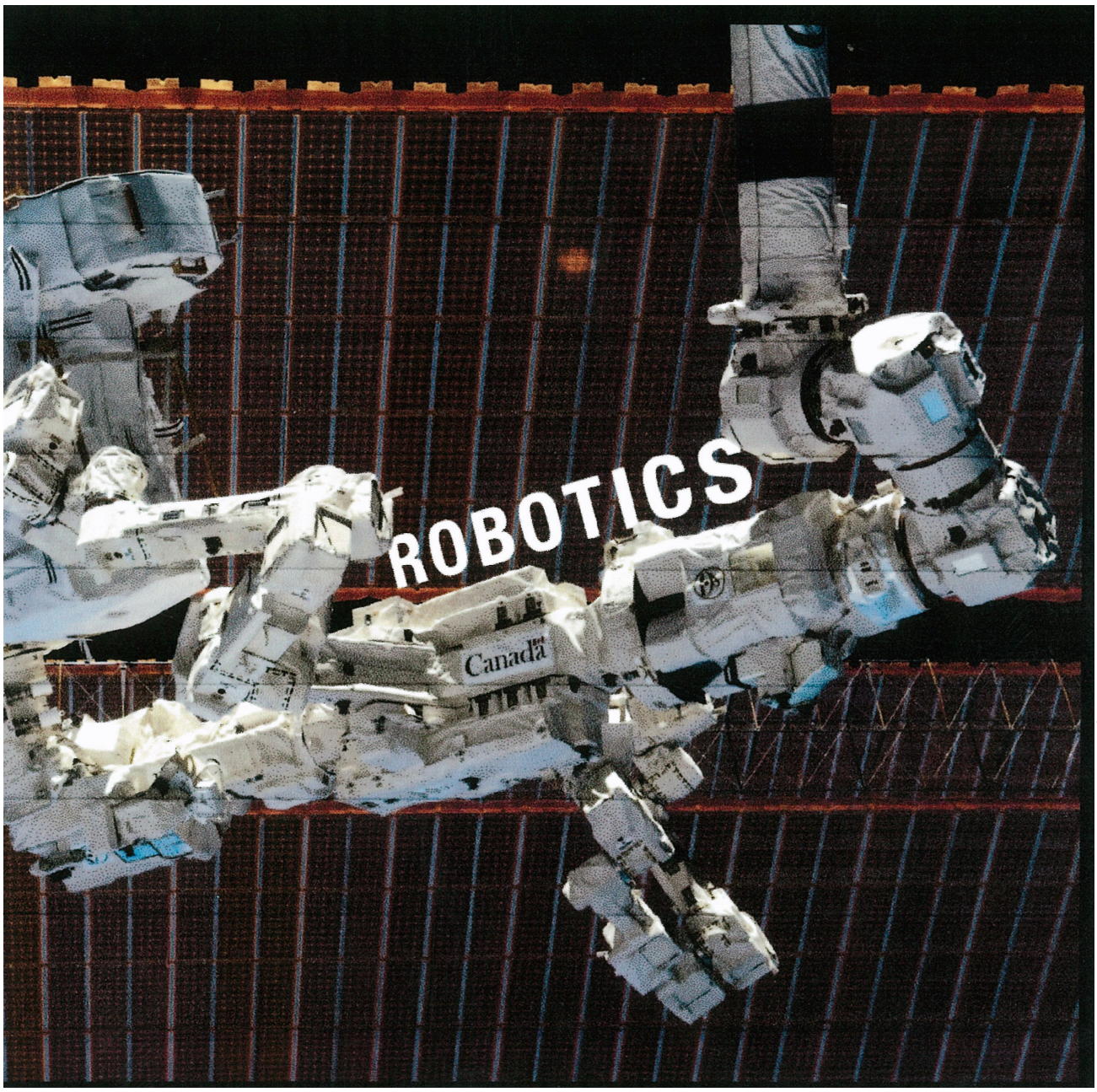


SOLID ROCKET BOOSTER (S.R.B.)

SOLID ROCKET BOOSTER (S.R.B.)

ELEMENTARY





by Lynn P. Hagan and Liz Elsen

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A TEACHER'S GUIDE TO THE SPACE STATION: PIECE BY PIECE

Bits and pieces—all are parts of the whole. The Space Station, like a living organism, cannot long survive without the interdependence of its parts. Likewise, nothing on Earth can long exist without parts working as a whole. The creation of a livable environment in space has resulted in a miniature world that utilizes processes and methods identical to those found in nature.

Truss Structure

The trusses are made of a material that does not change its size as it heats and cools. The construction team of astronauts will stack 16.4-foot cube trusses, as a basic building block, and will gradually build to the perimeter of the rectangle. The team will then construct a transverse beam to which the manned modules will be attached. The configuration is such that it is open-ended and well-suited to the outer space environment. The structure is strong and self-supporting.

Solar Arrays

The solar arrays of the Space Station are of a tried-and-true design. Being simply solar cells, they will be easily transported to and from the station via the Orbiter. The solar arrays will be unfolded after placement on the station. They will supply the energy to be used for the various functions of the Space Station. (These are also known as photovoltaic cells.)

Servicing Facility

The servicing facilities on the Space Station will function much as a repair center on Earth does. Disabled satellites, payloads, and free-flying vehicles will be refueled, assembled, berthed, repaired, and refurbished as needed. The functions within the Servicing Facilities will be carried out in EVA (extra-vehicular activities).

Axis Control

The alignment of the Space Station while in orbit is of critical concern. (The United States' first space station, Skylab, had an orbit which deteriorated to the point where it fell to Earth and was destroyed.) Gyros aboard the Space Station will be responsible for the station's attitude. Equal forces upon the gyros will bring the gyros back into their original position in the event of a change in the station's directional forces. At the appropriate attitude or position, the control thrusters will fire, bringing the gyros back into original position.

Solar Dynamic Collectors

The solar dynamic collectors are designed as a companion to the solar arrays. They are actually huge parabolic reflectors which capture sunlight and convert it into electricity for use aboard the Space Station.

Manned Modules

The manned modules are the places where the crews will live while aboard the station. All modules will be pressurized to 14.7 psi (sea level pressure). The modules will be able to handle 6-8 crew members. Like Skylab and the Space Shuttle, the modules will have all the comforts of home, including galley services, sleeping accommodations, etc.

Environmental Control and Life Support

Water will be obtained from a dehumidifier on board which will separate it from urine and waste water. Filtering methods are currently being considered for other water systems.

Air in the modules will be of the same oxygen and nitrogen mixture as on Earth. EVA suits will have a pressure of 8.4 psi, which is a higher pressure than the suits currently being used on the Space Shuttle (4.3 psi). The Space Station will be built by users of the low pressure suit, while development of a hard high pressure suit continues for eventual use aboard the Space Station.

Climate Control

Aboard the Space Station, the dynamics of heat transfer are a major concern. Functionally, the station thermal management system is divided into the areas of heat rejection (radiation), heat acquisition, and systems integration. New insulation and radiation techniques are being developed for the Space Station.

Recycling

As mentioned above, the Space Station will be recycling the air aboard, as well as body fluids, wash water, experimentation materials, and the like. Disposables are to be avoided as they will produce too much trash on long duration flights.

SPACE STATION: TRUSS STRUCTURE [1]

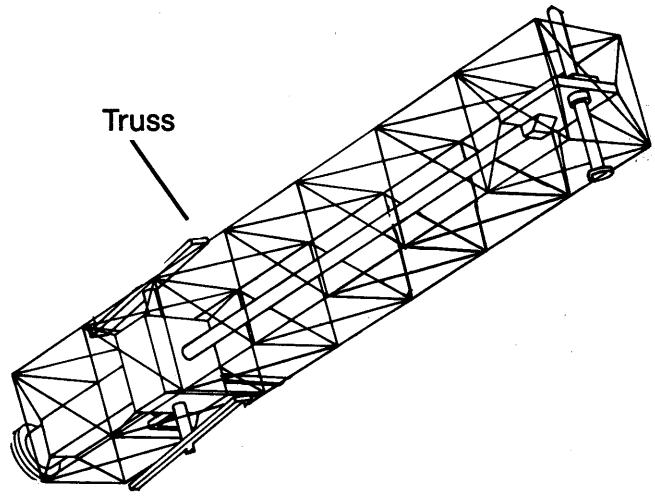
OBJECTIVE
Using a variety of forms, the students will construct models of the Space Station truss structure.

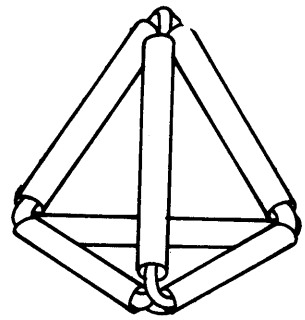
MATERIALS
- straws
- twist ties or pipe cleaners
- scissors

PROCEDURE[1]
1. Cut straws into sections of equal length.
2. Shape the twist ties into a "W" and insert as connectors.
3. Connect the straws by inserting them onto the twist ties.
4. Build several configurations.

QUESTIONS
1. Which of the structures built appeared to be the strongest?
2. What is the advantage to building structures of this type in space? (ease of transport, construction and unlimited size)
3. What similar shapes can you see in nature? (veins in a leaf, bee hives, etc.)

CONCEPTS
Truss structures can be quickly constructed, are light weight, and have infinite possibilities as to size and shape. They are the most logical construction style for space units.





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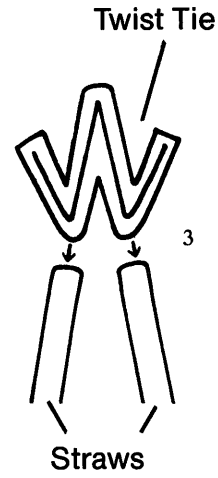


SPACE STATION: SOLAR ARRAYS[4]

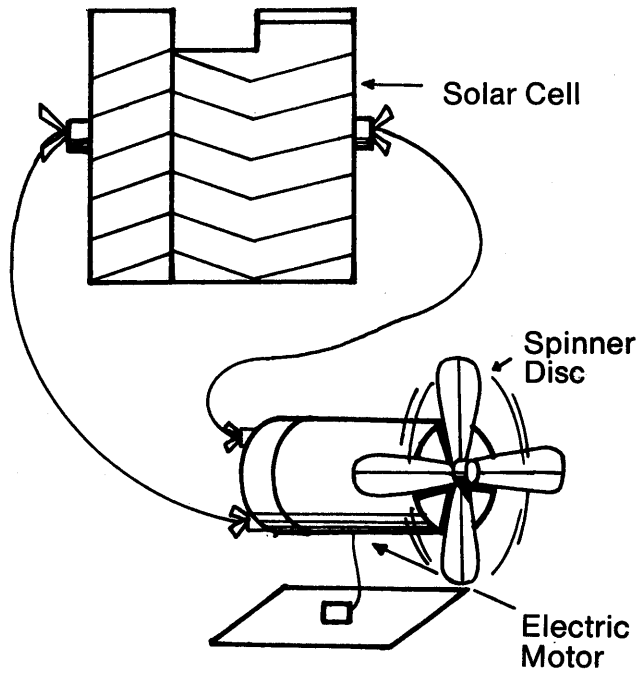
OBJECTIVES
The students will compare the transfer of light into electrical power for a motor with the way the Space Station will receive its power using solar arrays.

MATERIALS
- solar cell
- electric motor with spinner disc
- lamp with 100 watt bulb

(These materials are available at local electronics stores.)

PROCEDURE
1. Attach motor to solar cell in a closed circuit.
2. Aim the solar cell toward direct sunlight and take note of how fast the motor turns.
3. Then hold the solar cell near a 100 watt bulb, away from the sun.
4. Move the cell in and out of sunlight to regulate speed of motor.

QUESTIONS
1. What would happen if a mirror was placed behind the bulb? (motor turns faster)
2. How close must the bulb be to the cell to

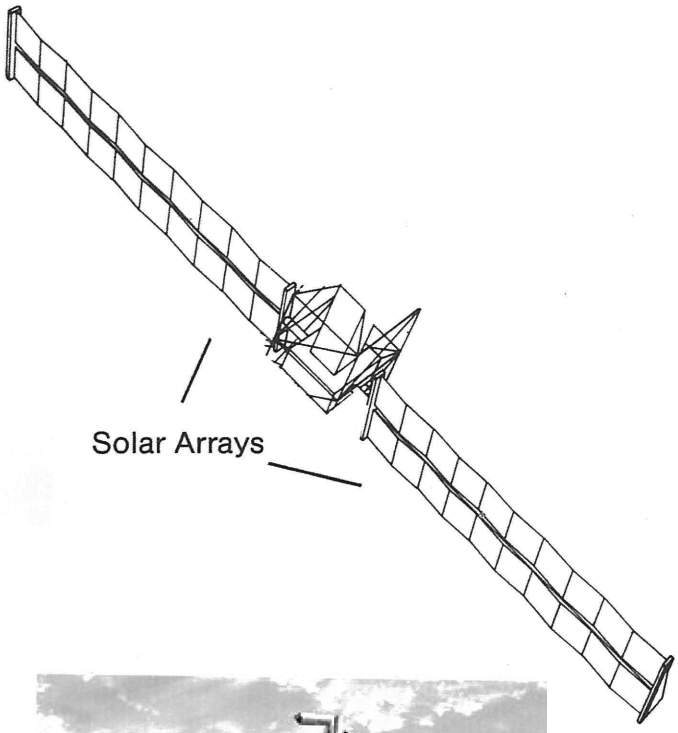


equal the energy from the sun?
3. What would happen if a different wattage of bulb were used? (the higher the wattage, the faster the motor turns.)
4. How does this experiment compare with the way the Space Station will get its power? (the Space Station is powered by the sun)
5. How does this compare to the way plants use sunlight? (plants convert sunlight into a usable form of energy through photosynthesis.)

CONCEPTS

Solar energy can be changed into electrical energy. All of the electrical energy that will be used on the Space Station will be generated by solar energy.

Teacher's note: Materials available at local electronics stores.



SPACE STATION: SERVICING FACILITY

OBJECTIVES

The students will compare and contrast the servicing facility aboard the Space Station with their local automobile service station on Earth.

MATERIALS

- pens
- pencils
- paper

PROCEDURE

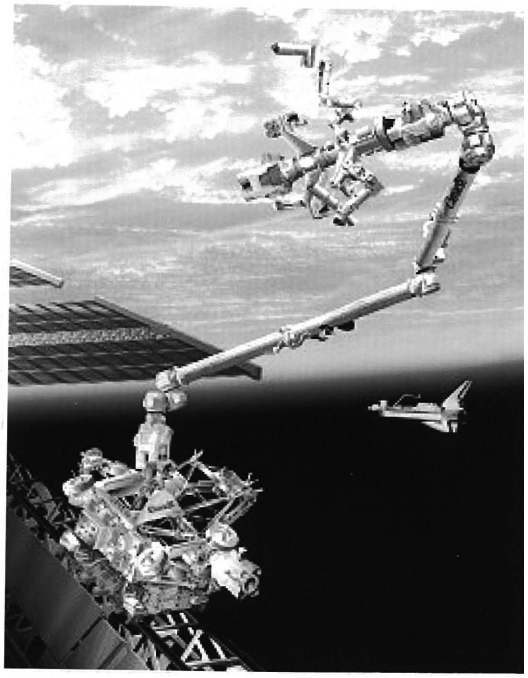
Discuss (or write a paper) comparing and contrasting the use and function of the service facility on the Space Station as compared to the student's family automobile repair shop. Take into consideration the questions below.

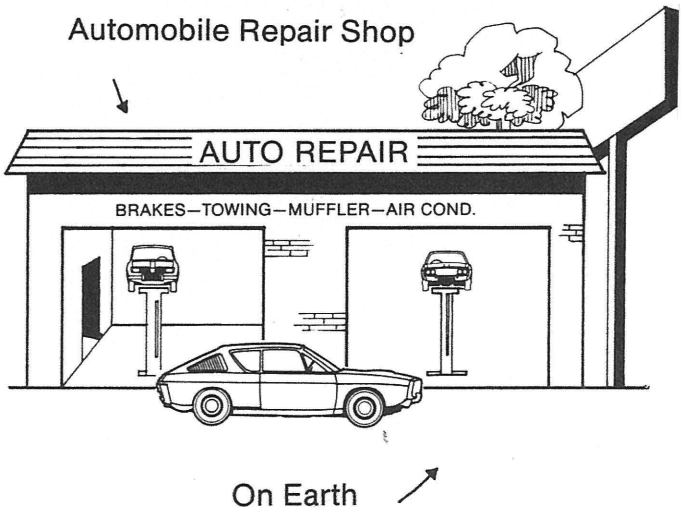
QUESTIONS

1. What kind of tools would you expect to find on the Space Station as compared to the auto center? (similar tools but tethered to the station)
2. What special type of suits must be worn in the Space Station service facility? (EVA) How do they compare with coveralls worn by auto repair personnel? (coveralls protect the user from dirt and grease and EVA's protect the user from the elements)
3. Would robots be practical helpers in either facility? (yes)
4. Would gas pumps in the local garage need to be redesigned for use in microgravity? (yes)

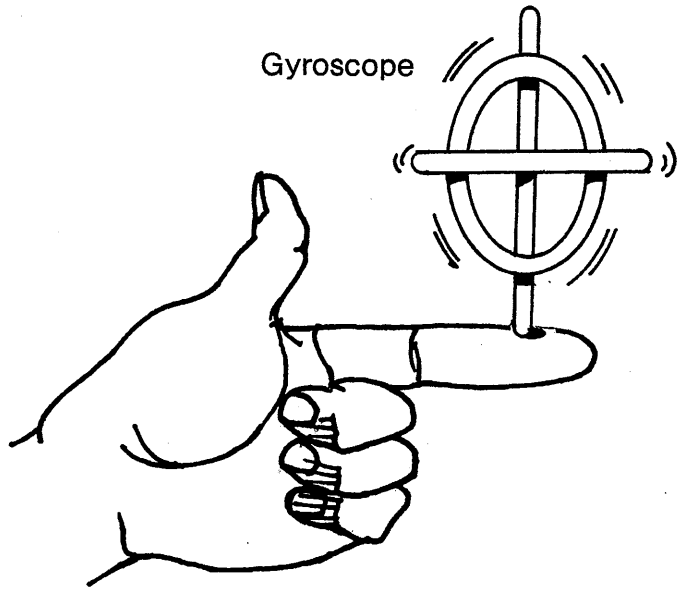
CONCEPTS

A necessary function of the Space Station will be to berth, store, assemble, repair, refuel (gas/fluids), refurbish and check out other space equipment without the need to return to Earth for such activities.





SPACE STATION: AXIS CONTROL[5]

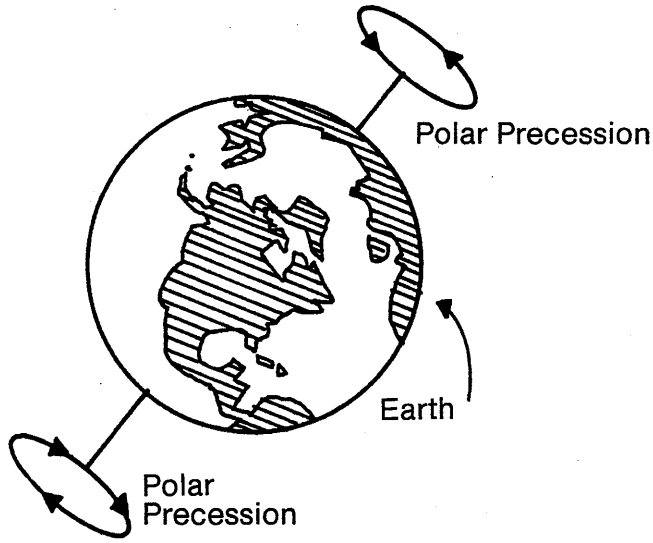


OBJECTIVE
The students will demonstrate the action of the gyroscope as it relates to Earth and to its utilization in space.

MATERIALS
- gyroscope (or)
- toy top

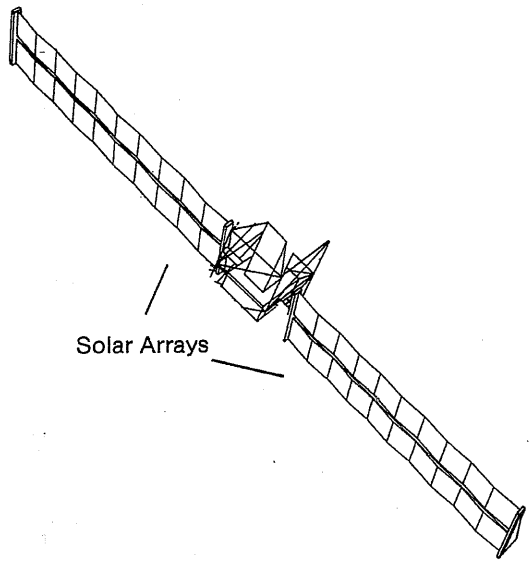
PROCEDURE
1. Spin the gyroscope and observe its behavior.
2. Pick up the gyroscope while it is spinning and feel the forces involved.
3. Set the spinning gyroscope on a student's finger.
4. Try to tilt the spinning gyroscope and observe its reaction.
5. Observe the gyroscope as it slows down. Note what happens to the axis.
6. Spin the gyroscope and point the axis in a different direction.

QUESTIONS
1. How does it feel to pick up a spinning gyro?
2. What happens when you push on the gyro with your finger? Which way does the axis point? (it moves at right angles to the direction of force)
3. What happens to the axis as the gyro slows down? (it wobbles—this is called precession)
4. The Earth is a huge gyroscope. As the Earth slows down, what is the effect on the North and South poles? (they will wobble)
5. How would you use the gyroscope on the Space Station to keep it stabilized? (information about its position would be used by the guidance system to help maintain the station's proper attitude in Space)



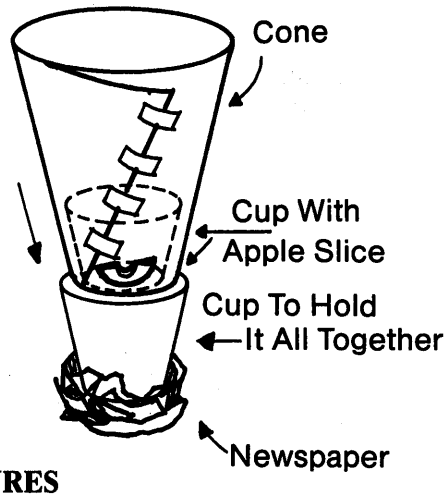
CONCEPTS
The gyroscope is an instrument that is sensitive to its position in space. It can be used to transfer this spatial information to the guidance systems, thus maintaining the Space Station in its correct attitude in space.

SPACE STATION: SOLAR ARRAYS[6]



OBJECTIVES
Using a simple solar collection device, the students will demonstrate the generation of heat from the light of the sun.

MATERIALS
- cardboard
- 4 paper cups, unwaxed
- white paper
- aluminum foil
- black paper
- plastic wrap
- scissors
- newspaper
- tape
- slices of apples
- 2 thermometers



PROCEDURES

1. Line two cups with black paper and place a slice of apple in each one.
2. Cover the tops of the two cups with plastic wrap.
3. Make two large cones, one with white paper lined with aluminum foil, the other with just white paper.
4. Wrap each cone around a cup with the apple slices inside.
5. Cover the bottom of each cone and cup with another cup to hold it together.
6. Crumple newspaper around the bases of the outside cups.
7. Aim the cookers at the sun.
8. Tape thermometers to cardboard (for ease of handling) and lower into cone. Record temperatures.
9. Cook until apples are done.

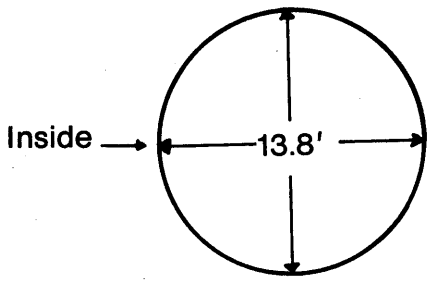
Teacher's note: This experiment takes a long time to complete and should be conducted on a warm, sunny day.

QUESTIONS

1. Taste the apples from each of the cookers. Which one of the cookers did the better job? Which cooker generated heat quicker? (aluminum lined one)
2. How do the cookers work like the solar collectors on the Space Station? (concentrate heat)
3. How does the aluminum foil on cookers relate to the mirrors on the solar collectors? (reflect and concentrate sun's rays)
4. Can you think of solar collectors on the Earth? (leaves)

CONCEPTS

Reflectors/mirrors on the solar collectors focus the sun's energy (light) enabling man to utilize the sun's energy by transforming it into other energy forms (heat and/or electricity).



SPACE STATION: MANNED MODULES[7]

OBJECTIVE

By building models or measuring space available, the student will demonstrate the dimensions of the quarters in which the Space Station astronauts will live and work.

MATERIALS

- tape measure
- chalk or string
- parking lot, gym or hallway

OR

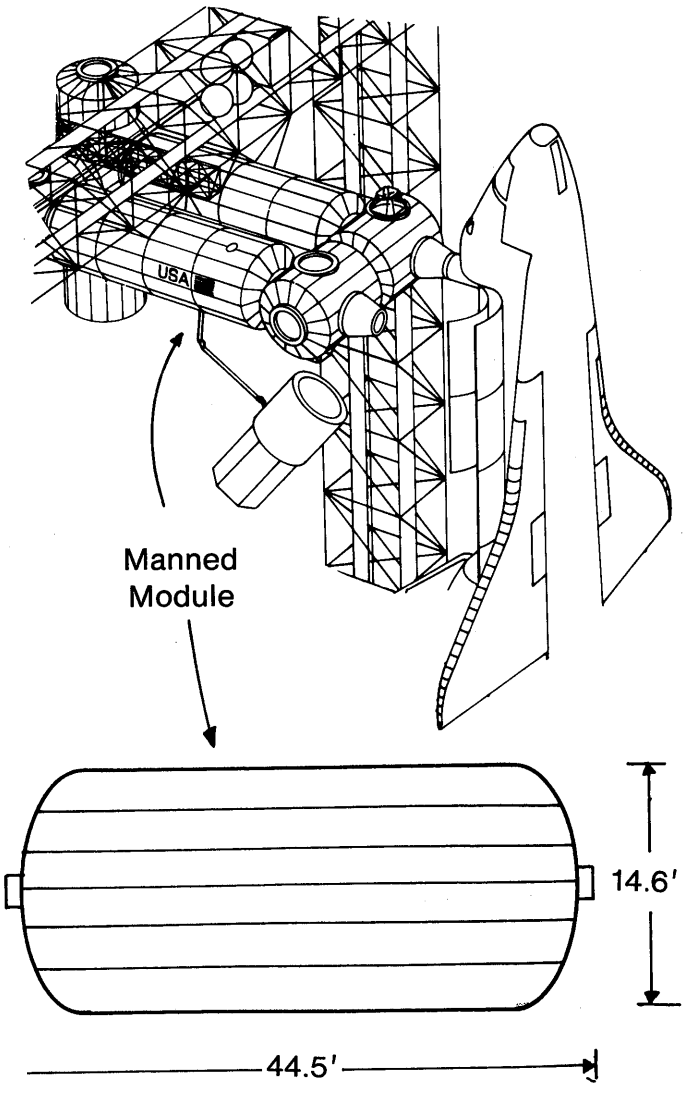
- discarded cardboard boxes
- tape measure
- good quality tape
- parking lot, gym, or hallway

PROCEDURE

1. Have students measure an outline of the habitation module by using either the chalk or the string.
2. Have six to eight students stand in the outline

OR

1. Have students measure, cut, tape and build a walk-in model of the habitation module.
2. Have six to eight students stand in the model.



QUESTIONS

1. How does this area compare to your room at home?
2. How does microgravity increase the feeling of room in the habitation module? (live in a 3-D situation utilizing all space)
3. Do you feel that you would have enough privacy during your stay on the Space Station? (probably not)
4. What types of animals on the Earth share close quarters? (ants, bees, etc.) How do they cope with the confines of a small area and a large population? (division of labor)
5. Can some of the more obvious problems be solved by training? By careful planning of space and time? Will routines and rules be essential? (yes)

CONCEPTS

Tight living quarters for six to eight adults for an extended period of time presents difficulties of a physical, spatial, and psychological nature.

SPACE STATION: TRASH PROBLEMS

OBJECTIVES

The students will solve a hypothetical math problem illustrating the amount of trash generated by a crew of eight during a one month stay on the Space Station.*

MATERIALS

- pens
- pencils
- paper

PROCEDURE

Relate the following scenario to the students:

Eight crewmembers have been aboard the Space Station for one month. They have been eating three meals a day for their one month aboard, and have been eating from all disposable utensils (forks, plates, cups, etc.). The Space Shuttle "Discovery" is on its way to exchange crews.

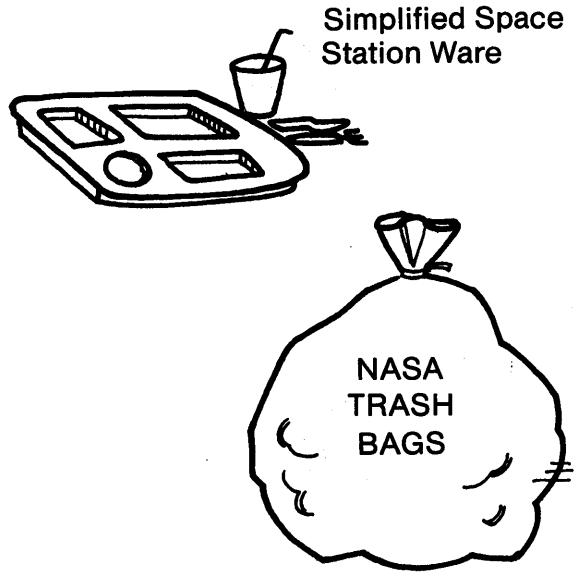
QUESTIONS

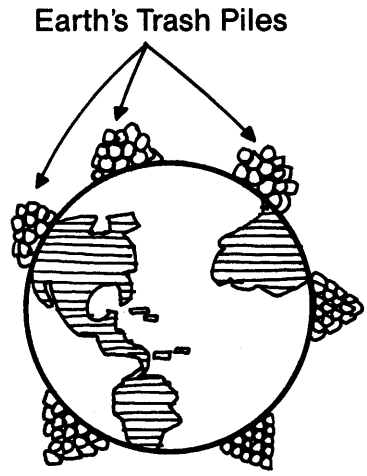
1. How many plates, knives, forks, spoons and cups will the Space Shuttle have to return to Earth? (720 of each)
2. If the crew had only one set of reusable tableware per crewmember, how many would have to be returned to Earth? (none)
3. Which is the more efficient way to handle the tableware—disposable or reusable? (reusable)
4. If the problem of trash affects the Space Station, how does that problem relate to the problem of trash on the Earth? (limited space on Earth, too)
5. If the Space Station will run out of room for the trash, will the Earth as well? (yes)

CONCEPTS

Trash generation is an ever growing problem to our plasticized, throw-away society—both on Earth and in space.

*Teacher's note: The Space Station will utilize reusable tableware.





SPACE STATION: A TRIP IN SPACE AND TIME

OBJECTIVES
After a discussion of the questions below, the students will compare and contrast a 1998 shuttle flight to the Space Station with a 1607 ship voyage to the Jamestown colony.

MATERIALS
- pens
- pencils
- paper
- research information on Jamestown voyages

PROCEDURE
Discuss (or write a paper on) the similarities and differences between a flight to the Space Station and a voyage to the Jamestown colony. Take into account the questions below to aid the students in forming their comparisons. Divide the discussion into basic needs for living and recreational activities.

QUESTIONS
1. What things would you need to live in space? (food, clothing, shelter) What did the early settlers of the continent need to satisfy their basic human needs? (built houses, made clothes, hunted, farmed)
2. If you were to fill a backpack with the things which are essential to life, both in space and on the sea, what would you take?
3. What are the nutritional needs of humans on their voyage? (balanced diet)
4. What would you add to your backpack to help you pass the long hours with little to do for fun?
5. How would you cope with the close quarters on both the ship and the Space Station? Do you feel that you would have enough privacy to have a comfortable journey? (everyone needs to have his own "space")
6. The safety of both the early settlers and the passengers on the Space Station is very important. What types of safety systems were available to each? (for example, life boats, life vests, bilge pumps on the ships, back-up computers, life support, emergency evacuation procedures on the Space Station)

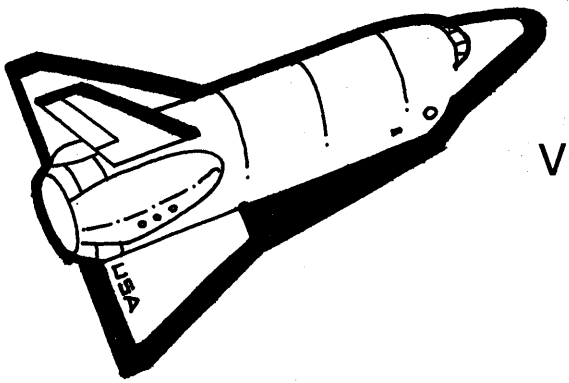
CONCEPTS
Basic human needs are universal and remain the same throughout time—whether on a schooner or a Space Station: food, clothing, shelter and mental stimulation. Safety is a major consideration for travel anywhere—on land, at sea or in the air.

SPACE STATION: BODY CLIMATE[8]

OBJECTIVES
The student will identify those types of materials which are suitable insulation in space and on Earth.

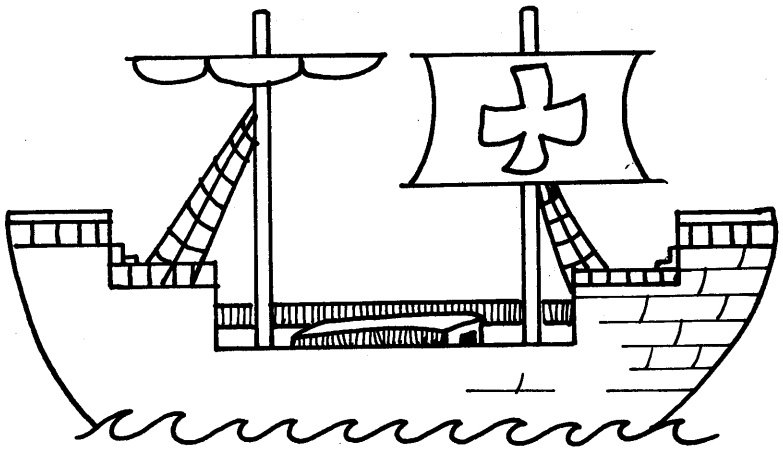
MATERIALS
- 4 2-liter bottles
- nylon material (cloth)
- cotton material (cloth)
- wool material (cloth)
- hot water
- thermometers
- pitcher

PROCEDURE
1. Wrap one bottle with the cotton, one with nylon, and one with wool cloth, and leave one unwrapped.
2. Fill all the bottles with the same amount of hot water, being careful that the water is not so hot as to cause injury or damage.
3. Using the thermometers, measure the temperature of the water approximately every 5 minutes for 40 minutes. Record findings.



1998 Travel

VS.



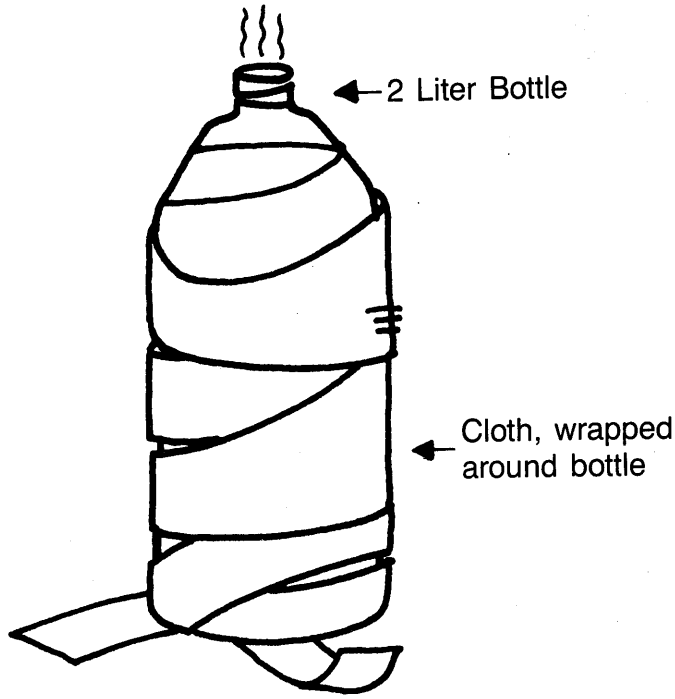
1607 Travel

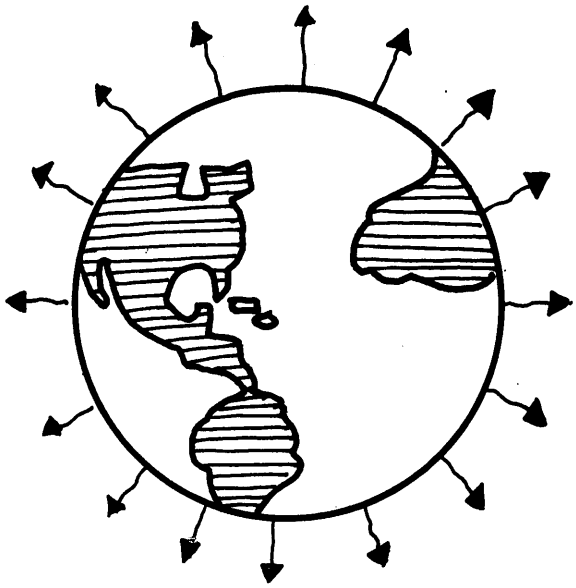
QUESTIONS

1. Which cloth keeps the water closer to its original temperature? (tightly knitted one)
2. Which bottle lost the heat the quickest? (unwrapped one)
3. How does this experiment relate to the way that the Earth regulates its temperature? (Earth radiates heat into atmosphere; cloudy day insulates Earth)
4. How does this experiment relate to the way animals are able to keep their body temperature constant? (fur, feathers, etc.) How do warm-blooded animals differ in their cooling systems from cold-blooded animals? (warm blooded animal's temperature remains constant)
5. How does this activity relate to the way spacesuits are constructed for EVA's (must retain heat/cold) Why must an astronaut be concerned about his body temperature in space? (no way to regulate temperature naturally)
6. Is space a hot place or a cold one? Can it be both? (yes)

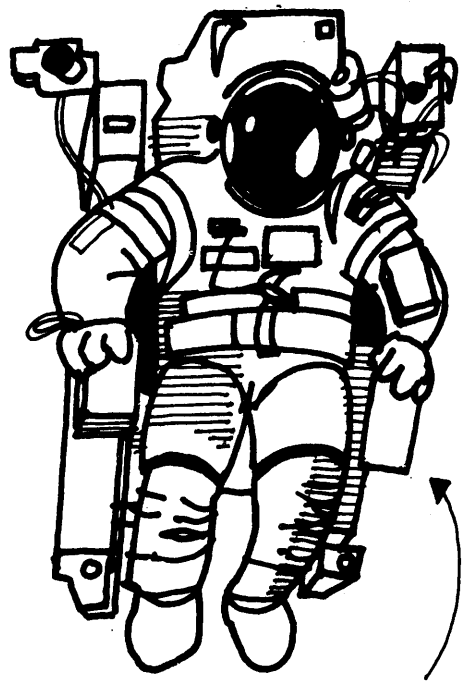
CONCEPTS

Proper clothing provides protection against climatic changes. Some fabrics retain heat, others "breathe" and allow air to flow through, thus allowing heat to escape. Thick cloth holds the air most effectively. Non-moving air is an excellent insulator. Clouds act as a layer of insulation in the Earth's atmosphere.





Earth Radiates Heat



Astronaut in extra vehicular suit and Manned Maneuvering Unit (MMU)

SPACE STATION: RECYCLED WASTE[9]

OBJECTIVE

The students will construct a filtration system and purify dirty water.

MATERIALS

- rubber band
- scissors
- 2-liter plastic bottle
- charcoal
- sand
- gravel
- pitcher
- cheese cloth
- dirty water
- glass

PROCEDURE

1. Cut the bottom out of the 2-liter bottle.
2. Place the cheese cloth over the mouth of the bottle and secure it with a rubber band.
3. Place in the inverted bottle: charcoal, sand, gravel.
4. Place a glass under the neck of the bottle to catch the clean, filtered water.
5. Pour dirty water into the bottle and wait for the filtered water to come through into the glass.

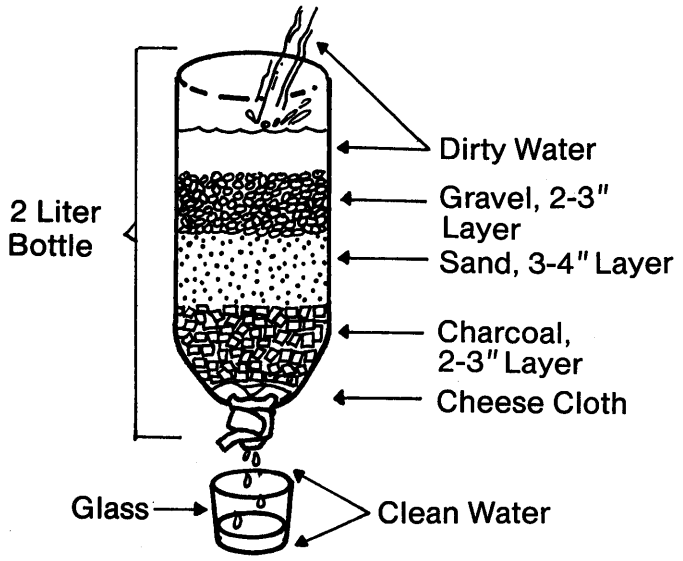
QUESTIONS

1. How do we on Earth purify the water we use? (water treatment plants, filters)
2. How does the Earth itself purify water that falls to the ground in the form of precipitation? (filters through layers of rock and earth)
3. Why is water which comes from underground cleaner than water from rivers? (filtered naturally)
4. Is it more practical for astronauts to recycle their water or to provide several gallons per person? (recycle water)
5. How much does a gallon of water weigh? (128 oz. or 8 lbs.)

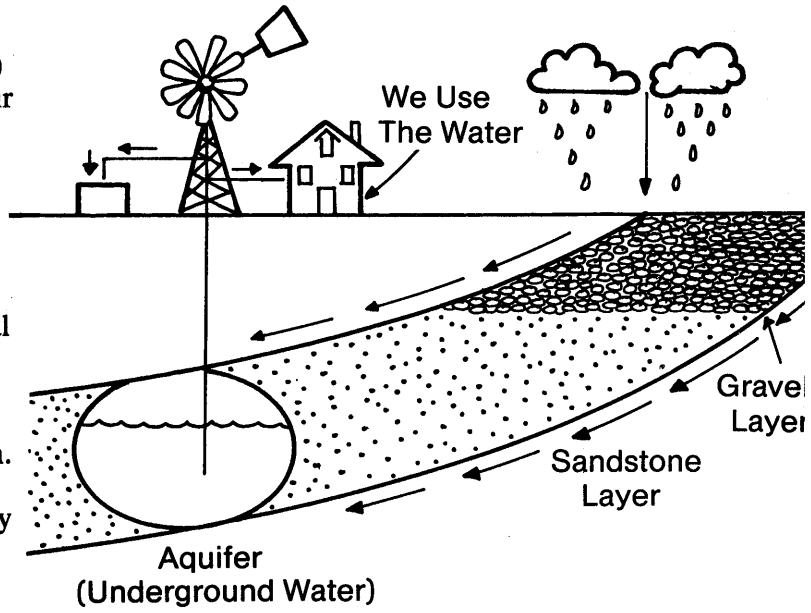
CONCEPTS

Water and fluids are purified by passing through successive layers of filtering material. It is essential to have such a recycling system in a closed environment. Earth itself is a closed environment. Other considerations: reservoirs of surplus liquid would take up too much space and weigh too much. It is not cost efficient to consider returning liquid waste to Earth, or to consider resupplying liquids by way of the Space Shuttle.

Water Purification System



Recycling of Water on Earth



GLOSSARY

astronaut
a person who flies in space, whether as a crewmember or passenger

axis
a line on which an object rotates

cold-blooded
having a body temperature which is regulated by environmental surroundings

docking
the technique of connecting two or more spacecraft in space

EVA
(Extra Vehicular Activity) to leave the spacecraft (spacewalk)

filter
a device for separating impurities from liquids and gasses by passing it through a porous substance

friction
force created by the rubbing of one object against another

gravity
force that draws all bodies toward each other

gyroscope
a wheel mounted in a ring so that its axis is free to turn in any direction

insulation
a covering of material which does not allow a transfer of energy

MMU
(Manned Maneuvering Unit) allows for mobility in space without the use of a tether

microgravity
near zero gravity (or weightless) condition

NASA
(National Aeronautics and Space Administration) the United States agency which is the governing body for space exploration and policy

orbit
the path taken by a satellite or spacecraft around a heavenly body

parabolic reflector
a bowl-shaped apparatus used to collect energy waves

payload
useful cargo aboard a spacecraft

photosynthesis
the method by which plants convert sunlight into usable energy

precession
the effect when a spinning top or gyroscope begins to slow down, causing a cone shaped rotation

precipitation
water falling from clouds in the form of rain, ice or snow

pressure
a force exerted against an opposing body

recycle
to use again and again

solar cell
apparatus which converts sunlight into electricity

spacesuit
clothing worn by an astronaut for EVA

STS
Space Transportation System (Shuttle System)

tether
a line attached to the spacecraft that keeps objects from floating off into space

truss
a rigid framework of beams and bars used for the support of a structure

vacuum
area devoid of air and gas

warm blooded
having a body temperature which is relatively constant

ELEMENTARY SECTION ENDNOTES

[1]Premise for this section based on The Young Astronaut Program, *Adventure Series: Recycled Science.* (Washington, D.C.: The Young Astronaut Council, 1986), Vol. 2, No. 1.
[2]The Young Astronaut Program, Vol. 2, No. 1.
[3]The Young Astronaut Program, Vol. 2, No. 1.
[4]Ideas for this section suggested by U.S. Department of Energy, *Space Science: Solar Energy.* (Washington, D.C.: U.S. Department of Energy, 1979), pp. 22, 23.
[5]Premise for this section based on The Young Astronaut Program, *Adventure Series: Toys That Teach.* (Washington, D.C.: The Young Astronaut Council, 1986), Vol. 1, No. 6.
[6]U.S. Department of Energy, p. 19, 20.
[7]Premise for this section based on Thomas Decair, *Teacher in Space Project.* (Washington, D.C.: Government Printing Office, 1985), p. 5.
[8]Premise for this section based on The Young Astronaut Program, *Adventure Series: Recycled Science.* (Washington, D.C.: The Young Astronaut Council, 1986), Vol. 1, No. 2.
[9]The Young Astronaut Program, Vol. 1, No. 10.

(1 Feb. 2012) - NASA astronaut Dan Burbank, Expedition 30 commander, uses the Space Linear Acceleration Mass Measurement Device (SLAMMD) in the Columbus laboratory of the International Space Station.

SECONDARY

Lt. Colonel Kathy Beauford
Civil Air Patrol

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3. Selection
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II. WHAT ARE MAN'S PSYCHOLOGICAL NEEDS AND HOW WILL THEY BE MET IN SPACE?

A. Social
1. A sense of community, a relational context: (national context; U.N. context)
2. Shared goals, esprit de corps: a union arising from common interests

B. Individual
1. Avoidance of crowding tension
2. Privacy
3. Quiet (avoidance of noise pollution)

III. WHAT ARE MAN'S CONTEXTUAL NEEDS AND HOW WILL THEY BE MET IN SPACE?

A. Physical knowledge of the universe
1. Pointed "inward": remote sensing of Earth:
   a. Ecological concerns: the food chain
   b. Pollution
      (1) Air pollution
      (2) Water pollution
      (3) Land pollution, waste disposal
2. Pointed "outward": remote sensing, exploration of the universe. (eventually "spaceport"—a jumping off place for interplanetary missions)

B. Knowledge of humanity's context:
1. An empirical philosophy for a technological society
2. What is philosophy?
   a. Ontology: What is real? What is reality?
   b. Epistemology: What is truth? How can truth be obtained?
   c. Axiology: What is of value?
      (1) Ethics: What is moral conduct?
      (2) Aesthetics: What is beauty?

C. Man's search for meaning

ORGANIZATIONAL RATIONALE

"Toto, I have a feeling we're not in Kansas anymore." [1]

No, Dorothy, the Space Station doesn't look a lot like Kansas, but it's more like home than you imagine. The Space Station will be a miniature Earth and will provide for man's needs as Earth does. We will create a small "Earth" in the Space Station, an Earth with its own biosphere, ecology, balance of forces, physical principles, uses, and purposes. While we come from "Earth Station," we will build a "Space Station" which will support man's life, needs, and endeavors. We will, in effect, be terraforming a section of space and creating a neighborhood that can help us to understand our own neighborhood "downunder."
Socrates said long ago that *"man must rise above the Earth to the top of the atmosphere and beyond, for only thus will he fully understand the world in which he lives."* By understanding how to design, build, maintain, and protect an environment in space, we can come to a better understanding of our crucial need to protect and nurture Earth. By going "out there" we arrive at a better look at "down here" and how to tend to our own garden.

"Explore inner space.
Discovery is not just for far-flung stars."
Eileen Lynch

Buckminster Fuller called our planet "Spaceship Earth" and called upon us all to tend to its needs and use it carefully. "This Island Earth" of ours is both our starting point and our ultimate destination. As T.S. Eliot said,

"We shall not cease from exploration... (and shall) get back to where we started... and know the place for the first time."

1 *The Wizard of Oz*, with Judy Garland, Ray Bolger, Bert Lahr, and Jack Haley. Dir. by Victor Fleming. Metro-Goldwyn-Mayer Pictures, 1939.

I. WHAT ARE MAN'S PHYSICAL NEEDS AND HOW WILL THEY BE MET IN SPACE?

A. THE SPACE STATION'S "ATMOSPHERE"

The Space Station will be another "Earth" and man will need an atmosphere to breathe. This atmosphere will need to be replenished as air is lost through small leaks and through opening the airlocks. The atmosphere will need to be "scrubbed" to keep it free of pollutants such as particles, carbon dioxide, and gasses from experiments and synthetic materials. Stringent safety requirements are incumbent upon all designs and materials specifications. While absolute safety, like perfection, still eludes mankind, every effort will be made to provide a safe space environment for man on the Space Station.

PREMISE

The Space Station's "atmosphere" must be generated initially, replenished as losses occur, and purified as polluting agencies soil it.

1. INITIAL GENERATION OF ATMOSPHERE

The station's first atmosphere will be brought from Earth Station. Though expensive in terms of cost, weight, and cargo space, the initial oxygen and nitrogen are likely to be "home grown" on Earth.

Note: Nitrogen will always be supplied from Earth.

2. REPLENISHMENT OF THE OXYGEN SUPPLY

a. Electrolysis is one of the options being studied for replenishment of the station's oxygen supply.

PHYSICS LESSON PLAN

OBJECTIVE

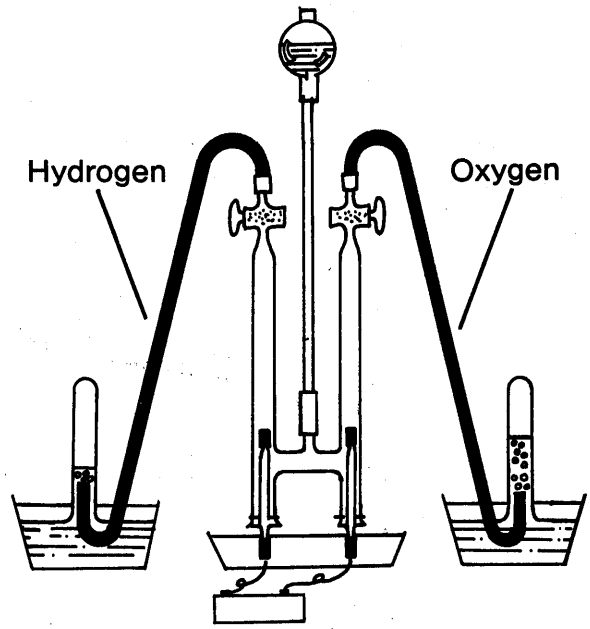
The students will participate in a lab experiment to demonstrate electrolysis, a process which may be used to generate oxygen aboard the Space Station.

TERMINAL OBJECTIVE

The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of the process.

MATERIALS

- Hoffman (H-type) set-up or Brownlee apparatus (See illustration.)
- a container of water (with a mild acid such as vinegar)
- wood splints and matches
- safety goggles
- test tubes



Standard Hoffman H-type apparatus

Note: Because an ignition source and hydrogen will be brought into contact in this experiment, stringent safety explanations and precautions are necessary. Astronauts aboard the Space Station will always follow established safety procedures.

PROCEDURE

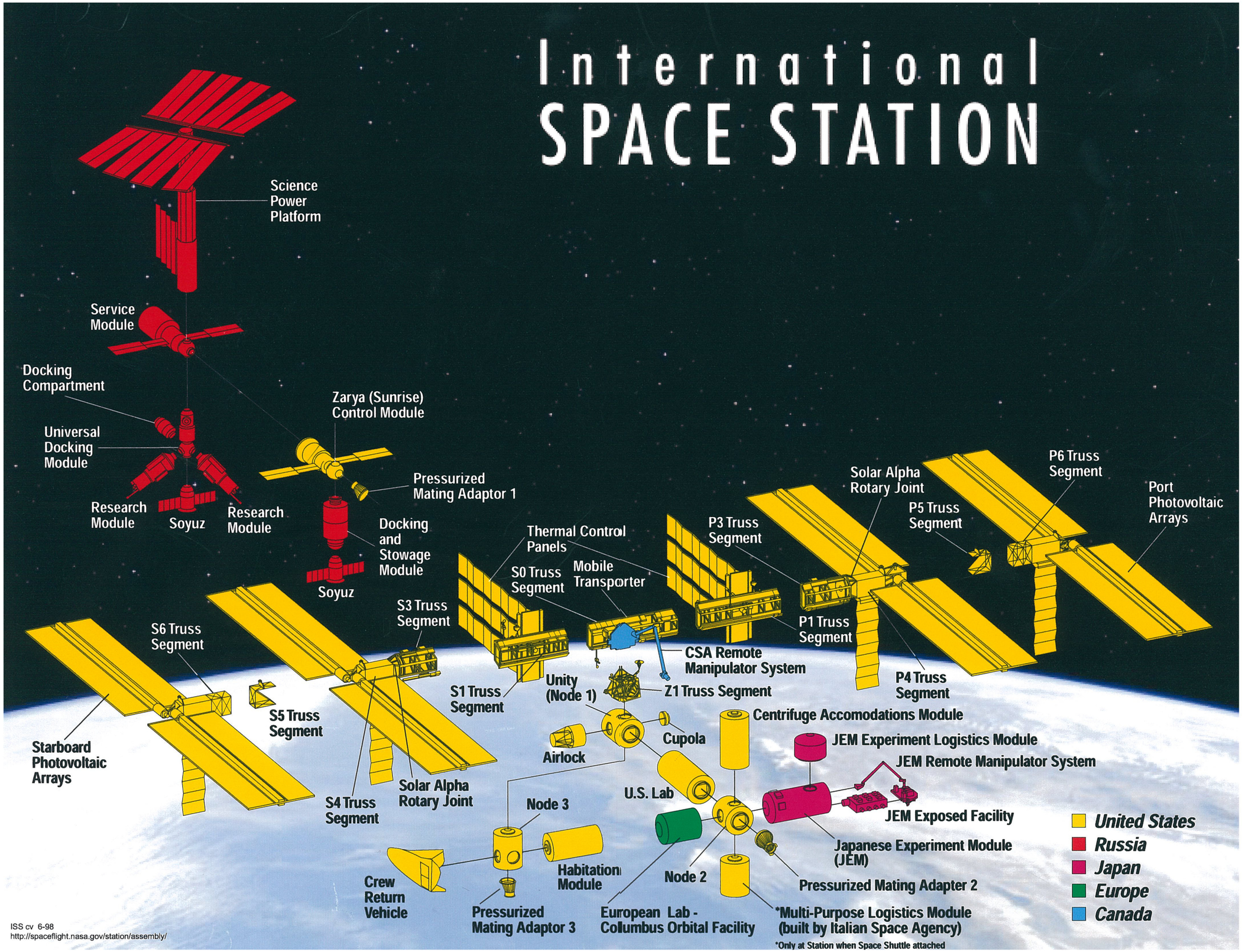
The teacher presents the theory behind electrolysis and then directs the students in safety and procedure as they perform the experiment. They will connect the platinum leads to the battery and place them in the container of water, adjust the power supply from the battery until bubbles rise from the water, measure the ratio of the hydrogen to the oxygen (2:1), and (if desired) ignite a *small* amount of the gasses for the purpose of identification.

Procedure for testing gasses: To identify the gasses present, use the following procedures. Open the stopcock on one side of the apparatus and, using an *inverted* test tube, collect *a small amount* of the gas. Use a match to light a wood splint and blow out both the match and the splint. Place a *glowing* wood splint in the test tube. If the splint re-ignites (flames up again), then oxygen is present.

To test for hydrogen, open the stopcock and, using an *inverted* test tube, collect a very *small* amount of gas. Use a match to light a wood splint; blow out both the wood splint and the match. Place the glowing wood splint near the mouth of the inverted test tube. There will be a popping noise if hydrogen is present.

Safety Note: Hydrogen is highly combustible so it is essential that only a small amount of gas be tested.

International SPACE STATION



ISS cv 6-98
http://spaceflight.nasa.gov/station/assembly/

ASSIMILATION
The students will ask and answer questions concerning the phenomena observed.

EVALUATION
Each student will produce a lab report which meets the criteria set by the teacher.

b. Hydroponics may be used to supply oxygen through photosynthesis.
Hydroponics (the growing of plants in a nutrient bath instead of soil) and aeroponics (the growing of plants in a nutrient mist instead of soil) are both viable means of producing oxygen in space. However, the Space Station will be too small for more than experimentation in the field. It is probable that one day hydroponics will allow man to set up the photosynthesis cycle in space, but that will have to wait for much larger Space Stations.

BIOLOGY LESSON PLAN

OBJECTIVE
The students will establish and monitor an experiment in photosynthesis, a process which one day may be used to generate oxygen on a Space Station.
TERMINAL OBJECTIVE
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedures followed and (3) notes observed physical phenomena of the process.
MATERIALS
- test tube and stopper
- a small sprig of Anacharis (Elodea) with an end bud and a snail. (Both are available from aquarium stores). If desired, a terrarium and soil, plants, snail, and worms may be used.
- Brom Thymol blue
- dechlorinated water or water which has been allowed to sit for a day.

PROCEDURE
The teacher presents the theory behind the photosynthesis cycle and directs students in setting up the cycle in a test tube, using Elodea, a snail, and dechlorinated water. The teacher sets up devices to measure the gasses in the test tube and directs the students in the measurement process. (Same can be done with a terrarium).
$CO_2 + H_2O$ = Carbonic acid which turns Brom Thymol blue to yellow!
ASSIMILATION
The students will ask and answer questions concerning the phenomena observed.

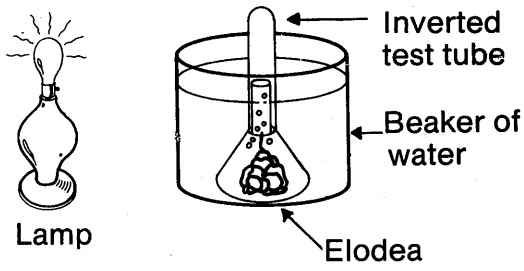
EVALUATION
Each student will produce a lab report which meets the criteria set by the teacher.
ENRICHMENT
To prove that photosynthesis has taken place, test for the presence of starch or chlorophyll in a leaf.
MATERIALS
- iodine
- alcohol
- hot plate (Do not use a source of open flame)
- leaves
- spinach
- acetone
- mortar & pestle
- filter paper
- test tube & stopper
- thumbtack
- petroleum ether

Safety Note: Because of the volatility of alcohol, stringent safety precautions and directions should be noted.
Remove the leaves from the plant and place them in hot water for one minute. Next place the leaves in alcohol that has been heated on a *hot plate* (not over an *open flame*) until the leaves turn white. Remove a leaf from the alcohol and add iodine to the leaf. If the leaf turns blue-black or purple, then starch is present. If the leaf is rust in color, then no starch is present.
To test for chlorophyll, one can use paper chromatography (the separation of the color pigments) to separate chlorophyll which has been extracted from leaves by use of acetone. Place either fresh or frozen spinach leaves in a mortar and add a small amount of acetone; grind this mixture with a pestle. Cut a strip of filter paper and notch it about ⅛ of an inch from the end. Use a thumbtack to attach the other end to the underside of a cork so that the strip can be lowered into a test tube. Dip a toothpick into the ground leaf-and-acetone solution and place a dot of it on the filter paper between the notches.

Allow the spot to dry and then repeat this step at least 6 more times, adding each time to the same dot. Place the strip in a test tube which is filled to a height of 1 cm with a solvent consisting of 92% petroleum ether and 8% acetone. Make sure that the pointed tip of the filter paper (and not the dot) just touches the solvent. Let this stand for approximately 25 minutes. Remove the strip and examine it for the presence of the following color bands:

Greenish yellow = chlorophyll a
Blue-green = chlorophyll b
Yellow = xanthrophyll
Orange = carotene

To test for oxygen, one can use Elodea to produce oxygen and then use the (glowing) wood splint test.



Safety Note: Only a small amount of oxygen should be tested because it speeds up combustion.

Cut the stem of a sprig of Elodea and place the sprig in the open end of a glass funnel. Fill both a beaker and a test tube with water. Put the glass funnel in the test tube. Invert this and quickly put it in a beaker. Place this set up next to a lamp. Watch for bubbles of gas. When enough gas has collected, use a glowing wood splint to test for the presence of oxygen which will cause the splint to re-ignite (flame). Note: The teacher may also want to set up control experiments without light or plants.

3. PURIFICATION OF "POLLUTANTS" IN THE ATMOSPHERE

The Space Station atmosphere will be polluted by exhaled carbon dioxide, particles, and gasses emitted from experiments and synthetics.

CARBON DIOXIDE POLLUTION

The hydrogen generated by electrolysis will be used in lithium hydroxide to "scrub" the atmosphere. Carbon dioxide "binds" to the LiOH and is removed from the air. The canisters of LiOH must be changed regularly but can be cleaned and recycled. Sensitive measuring instruments will be utilized to insure a safe atmosphere on the Space Station.

NASA scientists are also exploring the possibility of splitting carbon dioxide into oxygen and carbon.

PARTICLES

Particles of food, skin, fiber, etc., can be removed from the atmosphere by means of forcing the air through a system of filters (as central air conditioning does). The recycling system will also maintain air moisture.

OTHER GASSES

Various other gasses will be cleaned from the air by means of osmotic filters and binding agents. Unpleasant odors can be filtered or "covered" with pleasant scents. (One of the deprivations that astronauts noticed on extended stays in space was an absence of certain odors such as lemon and orange).

B. WATER

1. GENERATION

Since the early days of the space program, fuel cells have been used to combine oxygen and hydrogen to generate electricity. This process produced so much water as a by-product that it had to be vented overboard. Water will also be recovered from experiments, dishwashing, showering, and urine. Man's breathing and perspiring will also put moisture into the "atmosphere." (See the elementary section for ideas on a water filtration experiment.)

2. PURIFICATION

Astronauts may drink water recovered from urine. Distillation and phase change technology will produce drinkable water. Note: "Phase change" refers to changes in matter which skip the usual intermediate phase; for example, in sublimation, dry ice changes from a solid to a gas without going through the liquid phase.

CHEMISTRY LESSON PLAN: DISTILLATION

OBJECTIVE

The students will distill water much as astronauts will aboard the Space Station.

TERMINAL OBJECTIVE

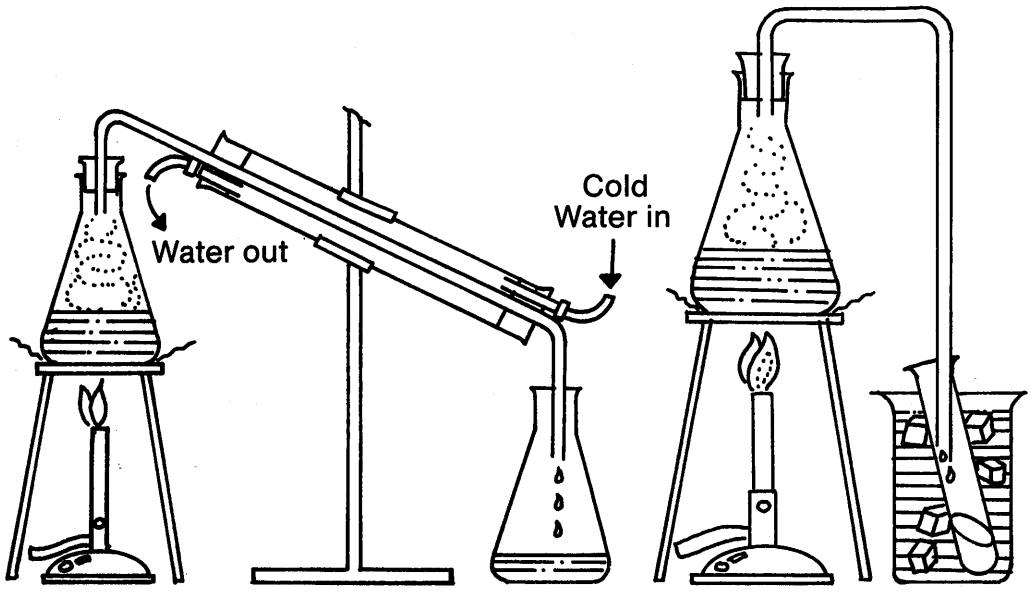
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of the process.

MATERIALS

- impure water
- distillation equipment
- Liebig condenser or similar apparatus (See illustration)

PROCEDURE

The teacher will present a lesson on the distillation process and direct the students in safety and procedure as they perform the experiment. They will distill the water and test the result for the properties of the test sample.



Liebig condenser [5]

Other apparatus [6]

ASSIMILATION
The students will ask and answer questions during the experiment.

EVALUATION
The students will produce a lab report which meets the criteria set by the teacher.

ENRICHMENT
For the impure water, substitute (1) water and alcohol or (2) water and vinegar or (3) water and salt or (4) water and potassium permanganate or (5) water and sugar.[7]

C. FOOD

1. GENERATION
Because of spatial limitations, the only food generated on the Space Station is likely to be sprouts. Most food will be supplied from Earth.

2. PREPARATION
Most of the preparation will occur on Earth. Food is cooked and prepared on Earth and supplied in the logistics module. The Space Station will probably have a convection oven, refrigerator, and freezer.

3. SELECTION OF FOOD

HOME ECONOMICS LESSON PLAN

OBJECTIVE
The students will design a balanced diet from the shuttle food and beverage list.

MATERIALS
- copy of the shuttle food and beverage list
- information on food groups, daily nutritional requirements
- if possible, a copy of "Space Shuttle Food Systems" (See bibliography).

PROCEDURE
The teacher will present a lesson on food groups, daily nutritional requirements, and the shuttle food and beverage list.

ASSIMILATION
The students will ask and answer questions about the lesson presented.

EVALUATION
Each student will produce a balanced diet for astronauts. (Three thousand calories a day is the shuttle standard. This is higher than the average caloric requirement because of the extra energy expended in a frictionless environment).

SHUTTLE FOOD AND BEVERAGE LIST

Foods

Almonds (NF)
Applesauce (T)
Apricots, dried (IM)
Asparagus (R)

Barbecue beef w/sauce (R)
Beef almondine (R)
Beef w/BBQ sauce (T)
Beef and gravy (T)
Beef, ground w/spice sauce (T)
Beef patty (R)
Beef steak (T)
Beef stroganoff w/noodles (R)
Bran flakes (R)
Bread (NF)
Breakfast roll (NF)
Broccoli au gratin (R)
Brownies (NF)
Butter cookies (NF)
Butterscotch pudding (T)

Candy coated chocolates (NF)
Candy coated peanuts (NF)
Cashews (NF)
Cauliflower w/cheese (R)
Cheese spread (T)
Chicken a la king (T)
Chicken consomme (R)
Chicken and rice (R)
Chicken salad spread (T)
Chili mac w/beef (R)
Chocolate covered cookie (NF)
Chocolate mints (NF)
Chocolate pudding (T)
Corn, green beans and pasta (R)
Cornflakes (R)

Dried beef (IM)

Eggs, scrambled (R)
Eggs, seasoned scrambled (R)
Eggs, Mexican scrambled (R)

Frankfurters (T)
Fruit bars (IM)
Fruitcake (T)
Fruit cocktail (T)

Graham crackers (NF)
Granola cereal (R)
Granola cereal w/blueberries (R)
Granola cereal w/raisins (R)
Granola bar (NF)
Green beans and broccoli (R)
Green beans w/mushrooms (R)

Ham (T)
Ham salad sandwich spread (T)

Italian vegetables (R)

Jam/jelly (IM)

Lemon pudding (T)
Life Savers (NF)

Macadamia nuts (NF)
Macaroni and cheese (R)
Meatballs w/BBQ sauce (T)
Mushroom soup (R)

Noodles and chicken (R)

Oatmeal w/raisins and spice (R)

Peach ambrosia (R)
Peaches, diced (T)
Peaches, dried (IM)
Peanut butter (T)
Peanuts (NF)
Pears, diced (T)
Pears, dried (IM)
Pecan cookies (NF)
Pineapple (T)
Potatoes au gratin (R)
Potato patty (R)

Rice krispies (R)
Rice pilaf (R)

Salmon (T)
Sausage patty (R)
Shortbread cookies (NF)
Shrimp cocktail (R)
Shrimp creole (R)
Soda crackers (NF)
Spaghetti w/meat sauce (R)
Spinach, creamed (R)
Strawberries (R)
Sweet 'n sour chicken (R)

Teriyaki chicken (R)
Trail mix (NF)
Tuna (T)
Tuna salad spread (T)
Turkey and gravy (T)
Turkey salad spread (T)
Turkey tetrazzini (R)

Vanilla pudding (T)

Beverages

Apple drink
Cherry drink w/artificial sweetener
Citrus drink
Cocoa
Coffee, black
Coffee w/artificial sweetener
Coffee w/cream
Coffee w/cream and artificial sweetener
Coffee w/cream and sugar
Coffee w/sugar
Grape drink
Grape drink w/artificial sweetener
Grapefruit drink
Instant breakfast, chocolate
Instant breakfast, strawberry
Instant breakfast, vanilla
Lemonade
Lemonade w/artificial sweetener
Lemon-lime drink
Orange drink
Orange drink w/artificial sweetener
Orange juice mix
Orange-grapefruit drink
Orange-mango drink
Orange-pineapple drink
Peach drink
Pineapple drink
Strawberry drink
Tea
Tea w/artificial sweetener
Tea w/cream
Tea w/lemon
Tea w/lemon and artificial sweetener
Tea w/lemon and sugar
Tea w/sugar
Tropical punch
Tropical punch w/artificial sweetener

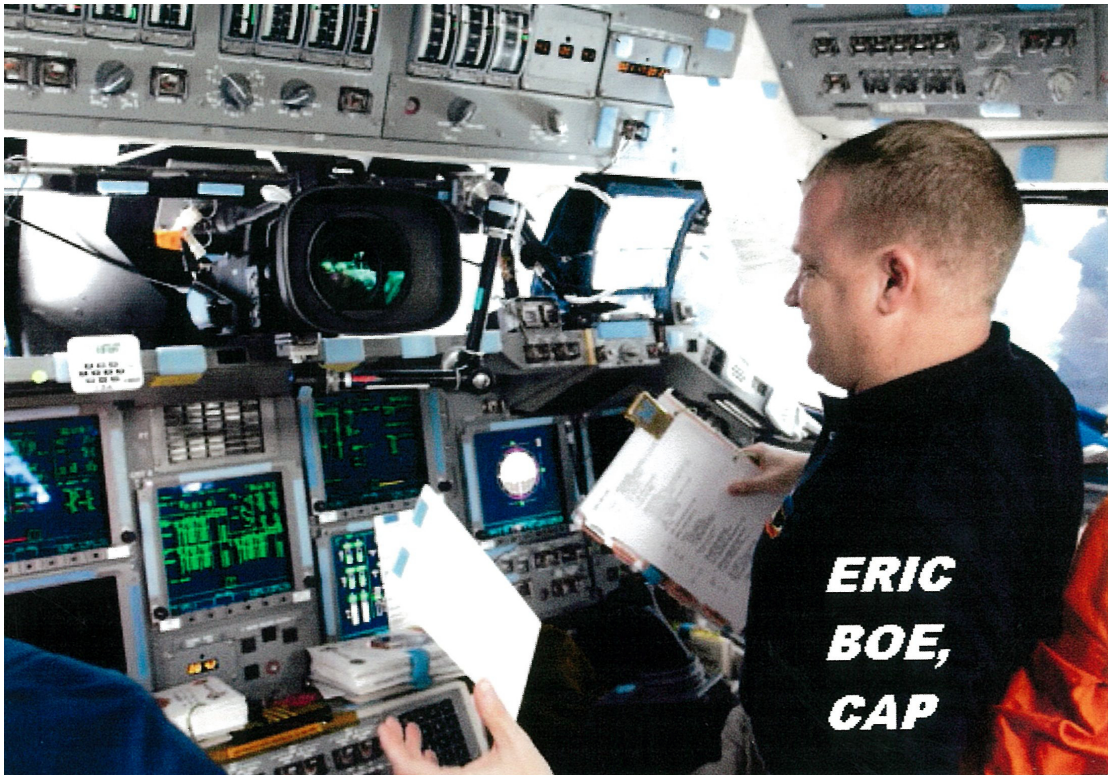
Condiments

Catsup
Mustard
Pepper
Salt
Hot pepper sauce
Mayonnaise
Taco sauce

Abbreviations

T	*Thermostabilized*
IM	*Intermediate Moisture*
R	*Rehydratable*
FD	*Freeze-Dried*
NF	*Natural Form*

[8]*Reprinted from NASA, "Space Shuttle Food Systems." Washington, D.C.: Government Printing Office, 1986, p. 14.*



MATHEMATICS LESSON PLAN

OBJECTIVE
The students will work out the possible menu combinations for their first six days on the Space Station.
PROCEDURE
The teacher will present probability theory and the menu of food choices listed below. The students will work out the possible food combinations.
ASSIMILATION
The students will ask and answer questions during the lesson.
EVALUATION
A probability problem solved correctly.
LESSON CONTENT:
A typical day's menu might be the following:

Meal I	Meal II	Meal III
Peaches	Frankfurters	Shrimp
Beef Patty	Turkey	Cocktail
Scrambled Eggs	Tetrazzini	Beef Steak
	Bread (2)	Rice Pilaf
Bran Flakes	Bananas	Broccoli
Cocoa	Almond	au Gratin
Orange	Crunch	Fruit Cocktail
Drink	Bar	Butterscotch
	Apple Drink (2)	Pudding
		Grape Drink

In general, each Meal III contains a main dish, a vegetable, and two desserts, with an appetizer included every other day. The food list contains 10 items classified as main dishes (M), 8 vegetable dishes (V), 13 desserts (D), and 3 appetizers (A). How many different menu combinations are possible in each of the first six days of flight, assuming no dish is repeated?

Solution:
The number of choices is tabulated below:

Day	A	M	V	D1	D2	Number of Combinations
1	3	10	8	13	12	37440
2	—	9	7	11	10	6930
3	2	8	6	9	8	6912
4	—	7	5	7	6	1470
5	1	6	4	5	4	480
6	—	5	3	3	2	90

[9]Reprinted from *Space Mathematics: A Resource For Secondary School Teachers* by Bernice Kastner, Ph.D., Department of Mathematics and Statistics, Simon Fraser University, Burnaby, British Columbia. NASA EP-175, U.S. Government Printing Office.

NOTE TO MATH TEACHERS
The source noted above is excellent and contains problems which relate to space navigation, orbital mechanics, remote sensing, and life in space. The chapter titles are:
1. Mathematical Aspects of Some Recent NASA Missions; 2. Computation and Measurement; 3. Algebra; 4. Geometry; 5. Probability and Statistics; 6. Exponential and Logarithmic Functions; 7. Trigonometry; 8. Matrix Algebra; 9. Conic Sections; 10. Calculus.

4. DISPOSAL OF FOOD WASTE
Trash will be compacted in a trash masher and then exposed to the vacuum of space and thus freeze dried. It will be stored in the Space Station logistics module for return to Earth.

D. SHELTER FROM THE "ELEMENTS" OF SPACE

1. PRESSURIZED MODULES
The atmosphere will be purer than that of Earth and will be comprised of oxygen and nitrogen but not the trace gasses which exist in our atmosphere. The air pressure will be 14.7 pounds per square inch (psi) which is sea level density. Aboard the Space Station there will be humidity, temperature, and slight "wind" as air is circulated. There should be no "rain." Excess heat will be radiated away from the station by radiators. As a safety feature, radiator pipes which run outside of the pressurized modules will contain freon; radiator pipes which run inside of the pressurized modules will contain water. (Because freon is an inert gas, its escape inside of the pressurized module could pose a safety hazard.)

a. RADIATION SHIELD: RADIATION CONCERNS
Just as the Earth's atmosphere shields us from the harmful effects of radiation, so also must the Space Station's walls shield its astronauts.

b. PROTECTION FROM SPACE DEBRIS
The module shell's outer layers will consist of an outer shell, insulation (mylar, kapton, or kevlar), a bumper shield, and a shell.

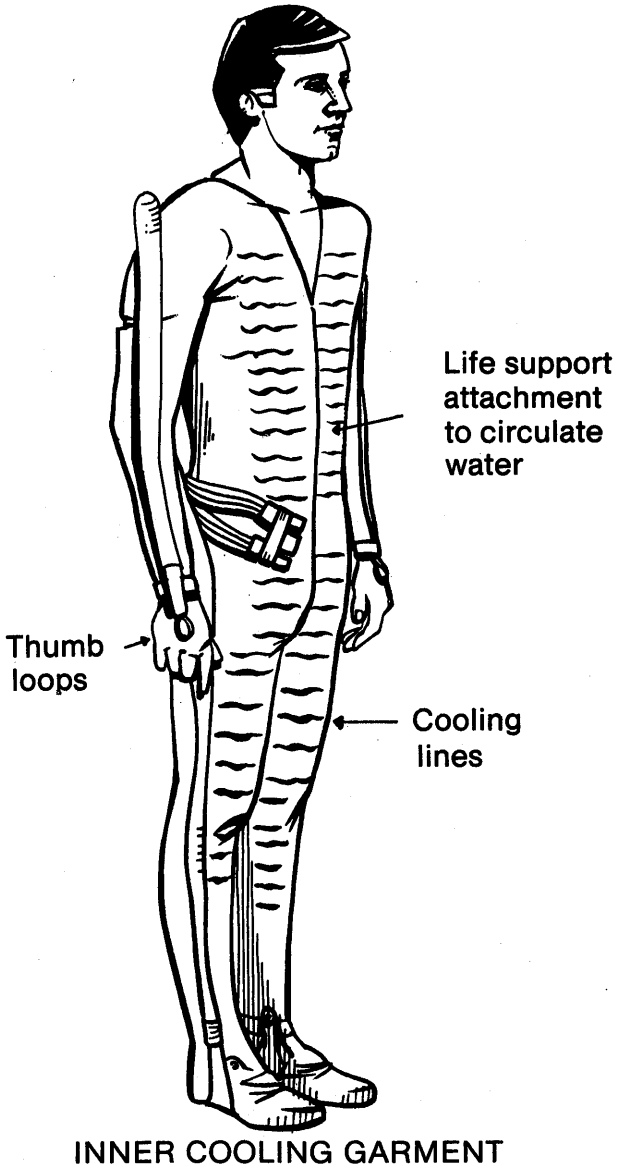
2. PRESSURIZED SPACESUITS
A spacesuit will be developed for use in the vicinity of the Space Station. It will be a hard, high pressure suit rated for 8.4 psi with either an oxygen/helium or oxygen/nitrogen atmosphere. This suit will obviate the need for two hours of prebreathing of pure oxygen that is required by the soft Space Shuttle suit before EVA, (Extravehicular Activity).

PHYSICS OR BIOLOGY LESSON PLAN

OBJECTIVE
In small groups, the students will fabricate a cooling system for a spacesuit, using tubing to carry cold water through the garment.

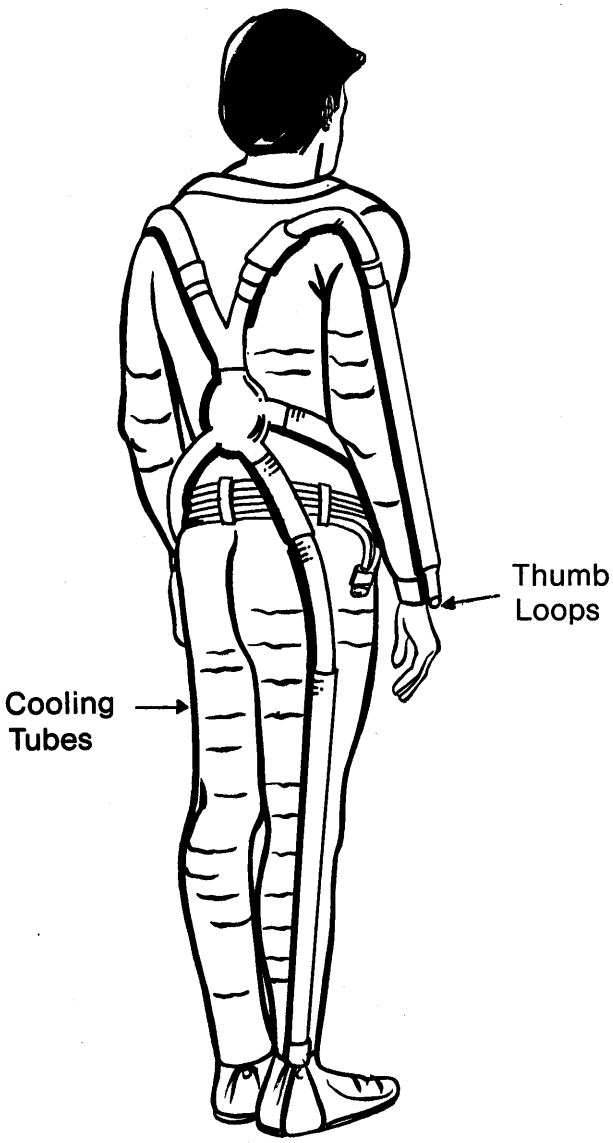
TERMINAL OBJECTIVE
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of the process.

MATERIALS
- an old jacket or large shirt or jumpsuit
- small gauge plastic tubing leading from the cold water containment and back into it, forming a "closed loop"
- thread
- small pump
- cold water in a containment



INNER COOLING GARMENT

INNER COOLING GARMENT



PROCEDURE
The teacher will present a lesson on cooling systems and monitor the students as they design, fabricate, and test a cooling system for efficiency.

ASSIMILATION
The students will ask and answer questions during the lesson.

EVALUATION
The teacher and the class will test and evaluate designs and choose the best design. The student will produce a report on the best design and the features which distinguish it from the other designs.

COMPUTER LESSON PLAN

OBJECTIVE
The student will write a brief description of the three main types of programming structure

TERMINAL OBJECTIVE
The students will write algorithms, flowcharts, and/or programs which will apply sequential (top down), selective (branching "if then"), and iterative (looping "for next") programming syntax. It is the teacher's prerogative to simplify or add to this unit to make it specific to the situation, programming language, and computer which he uses.

MATERIALS
This objective can be accomplished on the chalkboard or on paper if a computer is not available.

PROCEDURE
The teacher will teach a lesson on the difference between sequential (top down), selective ("if then" or branching), and iterative ("for next" or looping) program structure, using his own and student generated examples on either a computer, chalkboard, or poster. The teacher will lead the students in developing the concepts (see below) which will help them to write (A) a descriptive sentence on the program (B) an algorithm (word description of what each line of a program will do) and (C) flowchart and/or (D) a program which will establish a command/safety decision-making procedure for donning a Space Station spacesuit before an Extravehicular Activity (EVA). Note the importance of the safety check before committing one's life to a piece of equipment.

ASSIMILATION
The students will ask and answer questions during the lesson and as they write their algorithms, flowcharts, and/or programs.

EVALUATION
The students will produce one (or more) of the descriptions, algorithms, flowcharts, and/or program types taught, as the teacher desires. The student will briefly describe the three main programming structures. (Below)

LESSON CONTENT:

I. THERE ARE THREE FUNDAMENTAL PROGRAMMING STRUCTURES

A. SEQUENTIAL
Sequential program structure is also called "top-down" structure; that is, the program starts at the beginning ("top") of the program and runs straight through to the end ("down," "bottom") of the program. This type of program has no branching ("If then") statements or looping ("for next") statements.

B. SELECTIVE
Selective program structure is referred to as "branching" structure or "if then" structure; that is, this type of program starts at the beginning but includes program decisions whose answers will send the program in one of two directions. If A is true, then the program will go down a certain logic track; if A is not true, then the program follows another set of instructions to a conclusion.

C. ITERATIVE
Iterative ("looping" or "for next") program structure repeats an instruction without having to keep writing it into the program each time the instruction needs to be enacted.

II. THE STUDENT WILL COMPLETE THE FOLLOWING SENTENCE

"I will write (an algorithm or flowchart or program) which tells an astronaut how to put on a spacesuit; the program will use the _____ structure which _____."

POSSIBLE STUDENT RESPONSES

A. SEQUENTIAL
I will write (an algorithm or flowchart or program) which tells an astronaut how to put on a spacesuit; the program will use the sequential or "top down" structure which runs from top to bottom without any branching or looping statements.

B. SELECTIVE
I will write (an algorithm or flowchart or program) which tells an astronaut how to put on a spacesuit; the program will use the selective ("branching") structure which uses the "if then" statement.

C. ITERATIVE
I will write (an algorithm or flowchart or program) which tells an astronaut how to put on a spacesuit; the program will use the iterative or repeating ("looping") structure which uses the "for next" statement.

III. SAMPLE ALGORITHM ANSWERS

A. SEQUENTIAL ALGORITHM

Student decision-making: Lead the students into the realization that the algorithm below is not really safe because it does not tell the astronaut what to do if the safety check discovers faulty gear. (That is included in the next algorithm.)

Take out spacesuit.
Put on inner cooling garment.
  Conduct a check that the garment is worn properly.
Put on bottom of spacesuit.
  Conduct a check that the bottom is worn properly.
Put on torso of spacesuit.
  Conduct a check that the torso is worn properly.
Hook up cooling gear.
  Conduct a safety check of cooling gear.
Hook up electrical gear.
  Conduct a safety check of electrical gear.
Hook up breathing gear.
  Conduct a safety check of breathing gear.
Hook up communications gear.
  Conduct a safety check of communications gear.
Put on helmet.

B. SELECTIVE ALGORITHM

Student decision-making: Lead the students into the realization that the algorithm below *does* allow for corrective action if the safety check discovers faulty equipment. However, it should be noted that this program only *recycles* through procedures tried. If this does not correct the error, then the astronaut is caught *repeating* the action. Point out that this program needs a "bail out" provision if repeating the procedure does not correct the problem. (The bail out provision is in the next algorithm.)

Take out spacesuit.
Put on inner cooling garment.
  If inner cooling garment is not on properly, *then* go back to the last step.
Put on bottom of spacesuit.
  If bottom of spacesuit is not on properly, *then* go back to the last step.
Put on torso of spacesuit.
  If torso of spacesuit is not on properly, *then* go back to the last step.
Hook up cooling gear.
  If cooling gear is not working properly, *then* go back to last step.
Hook up electrical gear.
  If electrical systems are not working properly, *then* go back to the last step.
Hook up breathing gear.
  If breathing gear is not working properly, *then* go back to the last step.
Hook up communications gear.
  If communications gear is not working properly, *then* go back to the last step.
Put on helmet.
  If helmet is not sealed properly, *then* go back to the last step.

C. ITERATIVE ALGORITHM

Student decision-making: Lead the students into the realization that the algorithm below allows for corrective action when faulty equipment is found and also provides a bail out for further corrective action (replacement) but does not allow for repair.

Take out a spacesuit.
Put on a piece of the spacesuit.
If the piece is not working (or fitting) properly, repeat the step of putting it on (activating it) again.
If the piece is still not working properly, then discard it and put on a new unit of the type which was faulty.
If the replacement piece is not working properly, repeat the step of putting it on.
If the replacement piece is still not working properly, then discard it also and try another replacement piece.
If all available replacement pieces have proven to be faulty, then remove the spacesuit and abort the extravehicular activity (EVA).

Note: Because schools are using a variety of programming languages and different computers, it is the teacher's prerogative to write flowcharts and programs for the algorithms, if desired.

E. HEALTH

1. MEDICAL CONCERNS

a. SPACE SICKNESS

Scientists suspect that astronauts in the Mercury program did not experience "space adaption syndrome" (space sickness) because of their seated position and visual "up/down" perspective. It is thought that there is a relationship between visual perceptions and "up/down" prejudices, the middle ear, and the brain. In one Space Shuttle experiment, an astronaut wore a contact lens with rays painted on it. He stared at a rotating pattern while his eye was photographed. His eye was observed to rapidly rotate with the object, reach the end of its extension, return to base position, and attempt to rotate again. The causes of space sickness will be investigated further in the Space Station.

BIOLOGY LESSON PLAN: MOTION SICKNESS

OBJECTIVE
The students will participate in a lab experiment in balance and visual acuity in order to investigate motion sickness.

TERMINAL OBJECTIVE
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of geotropism (response to gravity).

MATERIALS
- a spinning platform or chair or a spinning subject

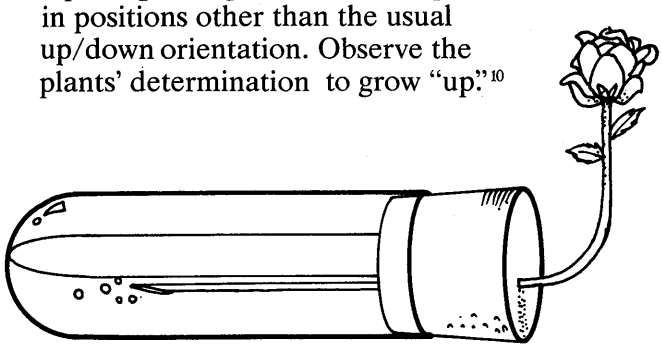
PROCEDURE
Safety Note—This experiment should be performed on a gym mat and obstructions should be removed from the area.

After the teacher presents a lesson in middle ear function, balance, eye fixation, and motion sickness, spin a volunteer until he feels dizzy. Stop him and observe his eyes in involuntary lateral spasms.

ASSIMILATION
The students will ask and answer questions about the experiment and learned physical response.

EVALUATION
The student will write a lab report which meets the criteria set by the teacher.

ENRICHMENT
Prepare 3 stoppered test tubes each containing a plant growing in water. Clamp the test tubes in positions other than the usual up/down orientation. Observe the plants' determination to grow "up."[10]



BIOLOGY LESSON PLAN: GEOTROPISM

OBJECTIVE
The students will participate in an experiment in biological gravity sensing mechanisms by confusing a crawfish as to up and down orientation.

TERMINAL OBJECTIVE
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of the experiment.

MATERIALS
- magnets
- live crawfish (crayfish)
- iron filings (which will be substituted for sand in the aquarium)

PROCEDURE
After the teacher presents a lesson in middle ear function and contrasts the gravity sensing granules in the human middle ear with the sand ingestion that a crawfish uses to sense gravity, the students will substitute iron filings for sand in the aquarium. The crawfish will take on the iron filings shortly after it molts. Then move the magnet around the aquarium to confuse the crawfish's sense of up and down. It will swim in what it feels is an up/down orientation.

ASSIMILATION
The students will ask and answer questions about the experiment and biological gravity sensing mechanisms and relate these to gravity and "microgravity."[11]

EVALUATION
The student will write a lab report which meets the criteria set by the teacher.

b. MINERAL LOSS: CALCIUM, POTASSIUM, SODIUM
Extended periods of weightlessness lead to loss of calcium from the bone and loss of sodium, potassium and red cells from the blood.

c. LOSS OF MUSCLE NITROGEN, LOSS OF MUSCLE TONE
One of the problems associated with extended periods of weightlessness is loss of muscle nitrogen and muscle tone. Since the heart is a muscle, this is a serious concern and one which may limit man's utilization of space for extended periods. Exercise has proven to be important in helping astronauts to overcome the effects of weightlessness. To date, no one consecutive stay in space has exceeded a year and no one is thought to have sustained any permanent damage from extended stays in space. Studies of these phenomena will continue on the Space Station.

PHYSICAL EDUCATION LESSON PLAN

The students will design new rules for the "Olympic Games in Space."

TERMINAL OBJECTIVE

The student will design new rules for one of the Olympic events in space.

PROCEDURE

The teacher will present a discussion of the effects of gravity and friction on movement in the traditional Olympic events.

ASSIMILATION

The students will ask and answer questions during the lesson.

EVALUATION

The student will list the new rules for his Olympic event in space and explain his reasoning for each.

ENRICHMENT

Design exercise machines, training machines, and/or workout machines for weightlessness.

2. HYGIENE

Anti-bacterial sponges and showers will be provided. Shower water will be recycled.

3. SANITATION

a. Ordinary waste will be compacted and returned to Earth.

b. Human waste: (1) Urine will be recycled (through distillation) or evacuated to space. (2) Solid wastes will be freeze dried and returned to Earth in the logistics module.

II. WHAT ARE MAN'S PSYCHOLOGICAL NEEDS AND HOW WILL THEY BE MET IN SPACE?

A. SOCIAL

1. A sense of community, a relational context—(National context; United Nations context). While the Space Station is a miniature Earth nation, it is also an international microcosm. The U.S. will be joined in the Space Station by Japan, the 10 nations of the European Space Agency (ESA), and Canada. Also, astronauts of many other nations may eventually work aboard.

CIVICS LESSON PLAN

OBJECTIVE

The students will research, prepare, and conduct a "United Nations" Security Council debate on the rights of nations in space.

SUGGESTED RESEARCH SOURCES

- Congressional Representative.
- The "Outer Space" treaty (below) from the Security Council of the United Nations, January 27, 1967.
- *Aviation Week and Space Technology Magazine,* 1986 issues contain a number of articles tracing the negotiations, disagreements, etc., occurring between the U.S. and the nations involved in the Space Station project.

PROCEDURE

The teacher will present a review of research techniques, debate techniques, and United Nations structure. The students will assume the roles of the nations involved and debate the issues raised in the *Aviation Week & Space Technology* articles and/or "The Outer Space Magna Charta" summarized below.

ASSIMILATION

The students will present a debate proposal to the teacher.

EVALUATION

The students will conduct the debate and vote on the issues.

LESSON CONTEXT

"A Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies."

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 (78 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 non-interference 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 extra-terrestrial organisms."[12]

12 Summary reprinted from *The Teacher in Space Project,* by Thomas P. Decair, "A Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies." Wash, D.C.: Government Printing Office, 1985, p. 15.

2. Shared goals, esprit de corps: A union arising from common interests, team spirit.

B. INDIVIDUAL

1. AVOIDANCE OF CROWDING TENSION

ART/PSYCHOLOGY/ENGLISH LESSON PLAN

THE PSYCHOLOGY OF COLOR AND ITS EFFECT ON MAN'S SENSE OF ROOM SPACE

Astronauts who have experienced extended stays in space have reported that they have missed colors, that the lack of color comprised a discomfort and a deprivation. Color has psychological effects on people who live in confined spaces for extended periods of time.

PREMISE

Colors, shapes, and patterns have psychological effects on emotional comfort/discomfort, "size" of environment (feeling of space), passive/aggressive behavior, work/energy levels.

HYPOTHESIS

Enclosed environments can be designed for psychological effect.

APPLICATION

The living module should have a restful effect on astronauts. The laboratory module should foster productivity.

ART OBJECTIVE

Design the color scheme for the habitation module or laboratory module of the Space Station.

PSYCHOLOGY OBJECTIVE

Given library research, present a report on the effect of color on aggressive/passive behaviors. Example: psychological studies have shown that a certain shade of pink has an enervating and calming effect. Studies have proven that a man can lift less weight after being exposed to a particular shade of pink. This pink has been used in prison containment tanks to calm fighting inmates.

ENGLISH OBJECTIVE

After limiting the topic, the student will utilize his library skills to write a report (or documented essay, or research paper) on some aspect of the psychological values of colors, shapes, and patterns and how they affect emotional comfort/discomfort, work/energy levels, and/or passive/aggressive behavior.

MATERIALS

- colored posters
- a system of attaching posters to the classroom wall
- Note: The same objectives can be attained with a scale model.

PROCEDURE

The psychological values of color, shape, and pattern. The students will design a wall of the Space Station habitation module or the laboratory module. Note: See the Space Station parameter sheet for module dimensions and details.

LESSON CONTENT

I. Color

1. Color values
   - Cool colors: Do cool colors have a relaxing effect? Can they make one feel cold? Do cool colors expand one's sense of room space?
     a. Blue
     b. Green
   - Warm colors: Do warm colors have a stimulating effect? Can they make one feel warm? Do warm colors "shrink" one's sense of room space?
     a. Yellow
     b. Orange
     c. Brown
     d. Mild pink
   - Hot colors: Do "hot" colors have a more intensified effect than warm colors?
     a. Hot pink
     b. Red
2. Primary vs. pastel: Do pastels have a softer feel to them than primary colors?
3. Shades: Light vs. dark: Do light colors "expand" one's sense of room space?

II. Line

- Curve: Do curves provide a soft, warm, mellow psychological effect to an area?
- Angle: Do angles provide an energetic, tense psychological effect which may quicken mood and add to work output? Is a vertical line static while a horizontal line is a line at rest and a diagonal line is dynamic?

III. Patterns

- Stripes: Do stripes make a room seem taller?
- Polka dots: Do polka dots make a room seem "busy"?
- Do mixed sizes of polka dots create the illusions of motion and perspective?
- Supergraphics: Do supergraphics make a room seem larger?

Note: The answer to all of the content questions above is "yes."

ASSIMILATION
The students will explain/justify their choice of color, shape, and pattern for the habitation module or laboratory module.
EVALUATION
Each student will construct a model of the habitation or laboratory module and a report justifying the rationale for his choices.

2. PRIVACY

3. QUIET (AVOIDANCE OF NOISE POLLUTION)
One of the ways that astronauts set up a "privacy space" is through control of sound. Some wear ear plugs for sleeping and for noise control. Many listen to music through earphones.

MUSIC LESSON PLAN

OBJECTIVE
The student will study music which has been written about outer space and space exploration. Examples: "Telstar" and Gustav Holst's "The Planets."
PROCEDURE
The students will research music titles which deal with space and space exploration. The class will choose a piece to learn and perform through voice or instrument.
ASSIMILATION
The students will ask and answer questions during the lesson.
EVALUATION
The teacher will evaluate the students' recital of the musical selection.
ENRICHMENT
Holst is purported to have written each of the planets' selections based on the resonating frequency of that planet.

Note: "Holst: the Planets" is available in Dolby™ "B" by Leonard Bernstein with the New York Philharmonic, Columbia Records, Inc., 51 W. 52 Street, N.Y., N.Y.

III. WHAT ARE MAN'S CONTEXTUAL NEEDS AND HOW WILL THEY BE MET IN SPACE?

Note: Contextual = relational. How are all things, beings, linked together in a sphere of interdependence and shared meaning? What is the hierarchy of importance of things and beings? What is man's relationship with the universe on the physical level and on the philosophical level of meaning?

A. PHYSICAL KNOWLEDGE OF THE UNIVERSE

1. POINTED "INWARD": REMOTE SENSING OF THE EARTH.
One of the major tasks of the Space Station will be to provide a systematic picture of the Earth on an ongoing basis. It will provide not only geological surveys for prospecting purposes, crop surveys for economic and political purposes, but will also provide a reliable platform for ecological study of the Earth and its ecosystems. Pollution monitoring will be a major part of this ecological study; prevention and recovery from pollution will become a more exact science. Air, water, and land pollution will be studied on an ongoing basis and will provide information which will enable man to administer the environment more responsibly.

a. ECOLOGICAL CONCERNS: FOOD CHAIN
During the 1970's, the "Environmental Decade," Congress passed the laws listed below in a national determination to protect the ecological balance which so affects the food chain. "The new laws, strong enough to challenge abuses to our environment, gave rise to new businesses and changed the operating procedures of old businesses. In many cases, new projects can no longer be undertaken without first seriously considering their effects on the environment of which we are all a part. Looking back on that decade, it is clear that the United States took a new direction in protecting environmental quality."[13]

ENGLISH LESSON PLAN

The students will research the space station on the web and write a report on its purpose, structure, or experiments.
PROCEDURE
Using the space station websites listed on page 59, the students will utilize the web to write a report (to the teacher's specifications) on one or more aspects of the space station.
ASSIMILATION
The students will consult the teacher on aspects of their report in progress.
EVALUATION
Utilizing standard criteria, the teacher will evaluate the student's report.

BUSINESS LESSON PLAN

OBJECTIVE
The Space Station will be a miniature Earth and will provide for man's needs as Earth does. Just as we must protect the fragile Space Station's environment, so also must we protect that of Earth. The student will study the effect of congressional legislation on local business practice as regards environmental issues on Earth and in space and then analyze the ecological, social, medical, and economic ramifications of same.

TERMINAL OBJECTIVE
The students will form groups to study the various methods of local businesses. They will analyze the economic and legislative restraints in effect in the area.

MATERIALS
- research materials
- list of laws dealing with environmental issues (See below)

PROCEDURE
The teacher will present a lesson on the legislation which affects the conduct of business in the local area. Perhaps speakers from local businesses and the local environmental watchdog agencies can be found for the class.

ASSIMILATION
The student will contact a local business and inquire into the impact which environmental legislation has had on its procedures and practices.

EVALUATION
The students will present their findings to the class and debate the feasibility of alternate solutions.

LESSON CONTENT
List of congressional legislation which deals with environmental issues—"The National Environmental Policy Act (1970)
Clean Air Act and Amendments (1963)
Water Pollution Control Act (1972)
Coastal Zone Management Act (1972)
Noise Control Act (1972)
Endangered Species Act (1973)
Toxic Substances Control Act (1976)
Resource Conservation and Recovery Act (1976)
Surface Mine Reclamation Act (1976)" [14]

[18]Reference: *The Class Project: Conservation Learning Activities for Science and Social Studies.* Wash., D.C.: The National Wildlife Federation, 1982.

Note: Since man is also an environmental element to be "conserved and protected," the Occupational Safety and Health Act (OSHA) could be a valid part of this study.

b. POLLUTION
(1) AIR POLLUTION
The Space Station will enable man to study the causes of air pollution and its effects in a systematic manner. One of the ambiguities associated with the acid rain problem is that it "comes down" far from its source. Systematic study of the atmosphere will enable us to identify sources of acid rain. The atmosphere will be studied through remote sensing from the Space Station and through satellites tethered to the Space Station. (One proposal suggests a satellite tether six miles long to drag a satellite through the upper atmosphere in order to study the ozone layer.) Upper atmosphere studies will also be conducted from high altitude planes. The Space Station will provide man with the most thorough sampling and study of the atmosphere to date.

ENVIRONMENTAL SCIENCE LESSON PLAN: AIR POLLUTION

The students will research and conduct a survey of air pollution in their area and prepare a report on same. The Space Station is a closed environment and its atmosphere must be kept clean.

TERMINAL OBJECTIVE
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of the experimental subject.

MATERIALS
- several wide mouthed containers filled with distilled water
- heat source for boiling out the water after collection period ends
- scales for weighing containers and pollution

PROCEDURE
The teacher will present a lesson on air pollution. The students will place the container in sites in the school area and add distilled water as evaporation occurs. After the desired collection period expires, the containers will be collected and the water boiled off. The resulting solids will be weighed. [15]

Note: Include property rights in the discussion of sites.

ASSIMILATION
The students will ask and answer questions during the course of the investigation.
EVALUATION
The student will produce a lab report or research report on air pollution.
ENRICHMENT
Put out a second set of containers and analyze this set for dissolved pollution. Use a magnet to sample magnetic minerals polluting the area.
Set up the collection phase with vertical cuplike wind filters of varying permeability. (These devices will require wind vanes to keep the collecting device facing into the wind.) Compare the acid rain in your area with the national norms.[16]

(2) WATER POLLUTION
The Space Station will enable man to study the causes of water pollution and its effects in a systematic manner. Water pollution poses a great danger to man because chemical and thermal pollution kill the natural biosystems upon which the oceans, and subsequently, the food chain, are based. If man "punches" a large enough hole in the food chain through dead areas of the ocean and decimation of key species, he will create an ecological nightmare. The Space Station will enable man to detect and correct the causes of water pollution.

ENVIRONMENTAL SCIENCE LESSON PLAN: WATER POLLUTION

The students will research and conduct a survey of water pollution in their area and prepare a report on same. The Space Station will provide a base for remote sensing of water pollution.
TERMINAL OBJECTIVE
The students will produce a lab report which (1) answers the questions raised by the experiment (2) describes the procedure followed and (3) notes observed physical phenomena of the experimental subject.
MATERIALS
- several widemouthed containers with strings (for lowering the container into the water to be sampled)
- papers to measure the pH levels of the water collected
- devices for analyzing the water collected

PROCEDURE
The teacher will present a lesson on water pollution. The students will take water samples at various sites in the school area, especially near discharge pipes from area chemical plants, if any. The water will be analyzed for pollution. Note: Property rights should be included in the discussion of collection sites.
ASSIMILATION
The students will ask and answer questions during the course of the investigation.
EVALUATION
The student will produce a lab report or research report on water pollution.
ENRICHMENT
Compare the water pollution in your area with the national norms.

(3) LAND POLLUTION: WASTE DISPOSAL
The Space Station will enable man to study man's land management, detect problems, and correct them. The effects of farming, fertilizers, pesticides, erosion, strip mining, and waste disposal will be studied from orbit on an ongoing basis. Hopefully, man will be able to respond to causes of pollution in time to prevent such poisoned areas as Love Canal.

SOCIAL STUDIES LESSON PLAN

The student will study the waste (solid waste, nuclear waste, and sewage) disposal methods employed in their area and analyze the ecological, social, medical, and economic ramifications of same. Living and working aboard the Space Station will generate its own waste pollution which must be disposed of safely.
TERMINAL OBJECTIVE
The students will form groups to study the various methods of waste disposal in their area. They will analyze the economic restraints in effect in the area and evaluate the land pollution.
MATERIALS
- research materials

PROCEDURE
The teacher will present a lesson on disposal methods in general. The students will contact local government agencies for information on the local disposal methods employed. Perhaps speakers can be found for the class. Waste disposal procedures aboard the Space Station may also be discussed.
ASSIMILATION
The students will research the subject as a group and prepare a report.
EVALUATION
The students will present their findings to the class and debate the feasibility of alternate solutions.
ENRICHMENT
Debate the pros and cons of nuclear energy: cost, safety, waste disposal, energy. Compare the land pollution in your area with the national norms.

2. POINTED "OUTWARD": REMOTE SENSING, EXPLORATION OF THE UNIVERSE
Man seeks his relationship with the universe and exploration is one of his natural activities. Answering our questions about the physical universe can help man to understand his place in the grand scheme of things. From where did we come? Where are we going?
Experiments on the Space Station will help us to see and sense the universe and find answers to our questions.
The Space Station will enable man to do experiments and sensing in astrophysics because only in outer space can we find access to the entire range of the electromagnetic spectrum. "Celestial objects emit radiation across the spectrum from lowest energy, longest-wavelength radio through infrared, visible, ultraviolet, x-rays, and highest-energy, shortest-wavelength gamma rays. Virtually all of our knowledge of celestial objects is derived from observation of electromagnetic radiation. Each wavelength carries information about its source and about physical processes occurring there. Of the 20-odd decades of electromagnetic radiation that reach the top of the atmosphere, only 5 decades penetrate to the ground. Thus, on Earth we have access to a mere fraction of the available information; to open all the channels and learn more, we must do our research in space."[21]
Eventually, the Space Station will become a "spaceport" for the assembling and launching of exploratory missions. (There is speculation that there may be another "space race" between the U.S. and Russia and that Mars will be the next major objective.)

B. KNOWLEDGE OF HUMANITY'S CONTEXT
1. A PHILOSOPHY FOR A TECHNOLOGICAL SOCIETY
Hypothesis: The unofficial philosophy of science is realism. Technological man's present activity in relation to understanding the universe and his place in it is characterized by the scientific method which is based on the philosophy of realism.

PHILOSOPHY/SOCIAL STUDIES LESSON PLAN

The students will debate the hypothesis that the philosophy of science is realism.
TERMINAL OBJECTIVE
The student will write a report arguing for or against the hypothesis.
PROCEDURE
The teacher will present a lesson on realism and the scientific method.
ASSIMILATION
The students will ask and answer questions during the lesson.
EVALUATION
The student will write a paper arguing for or against the hypothesis, responding to the areas of inquiry listed below.

LESSON CONCEPTS
2. WHAT IS PHILOSOPHY?
Philosophy is the study of reality and its underlying laws, purposes, and meanings. While a philosophy does not draw from matters of faith, it does not deny them; they are of a different realm.
a. ONTOLOGY: REALITY
Ontology is a study of the nature or essence of reality. Ontology answers the questions "What is real? What is reality?"[18]
Realism holds that reality consists of "a world of things which is identical with the physical experiential (universe) that man inhabits. Reality exists on its own;" [19] independent of our knowledge of its specifics. Objective reality consists of the concrete and physical. Ideas, ideals, emotions, and beliefs are real, though they are not corporeal.

b. EPISTEMOLOGY: TRUTH

(synonym: criteriology). Epistemology answers the questions "What is the nature of truth? What is knowledge? How can truth or knowledge be obtained?"[20]

Realism propounds that truth is "observable fact" and holds to the "spectator theory of sensation and correspondence."[21] In other words, truth can be detected and observed by man, the observer, the spectator. If what man thinks he has observed as truth *corresponds* to what is true outside of his mind, then he has found truth.

"A statement is true if it can be verified by empirical knowledge."[22]

The scientific method is a specific tool through which we come to categorize and understand reality and the nature of the physical universe and its laws. The replication inherent in the scientific method is the basis for our confidence in its discoveries.

c. AXIOLOGY: VALUES

Axiology answers the questions "What is the nature of values? What is of value?"[23]

(1) ETHICS

"What is moral conduct?"[24] What is of value in human interaction? Realism holds that ethics can be derived from the natural moral law, that there are certain standards of human conduct that are universal; for example, the proscription against murder is universal.

(2) AESTHETICS

"What is beauty? What is beautiful?"[25] Realism holds that "beauty is found in the order of nature and the universal principles that govern nature: regularity, orderliness, consistency." The realist artist looks for "balance, regularity, authenticity, and symmetry"[26] in nature and then reproduces them through the judgmental filter of his mind. The artist portrays the logic and order of nature.

Note: This is based on Aristotelean realism.
Reference: Dr. Glenn M. Hymel, *Philsophy of Education: Instruction Manual.* New Orleans, Louisiana, Loyola University of the South, 1979.

C. MAN'S SEARCH FOR MEANING

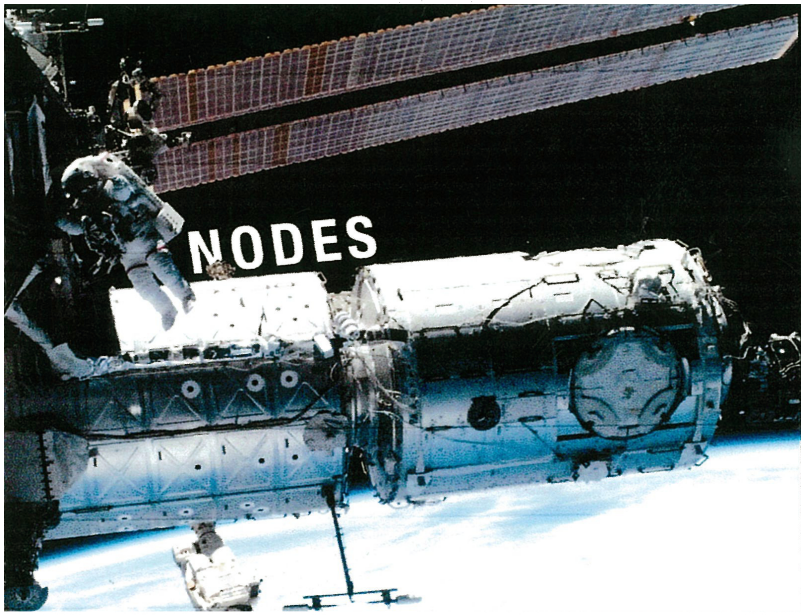
One of the areas of investigation of man's search for meaning is his relationship to reality. How do things fit together? What is man's relationship to the universe in general and to the Earth specifically? How will the Space Station enhance man's understanding of the meaning of things? Where does man fit between nature and technology?

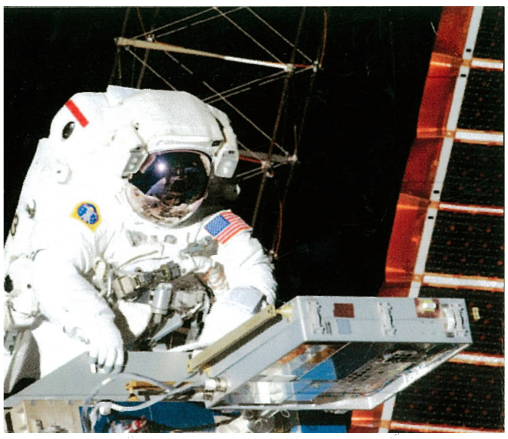
ENDNOTE

The future of man may well lie in his ability to understand causes and effects, events and consequences. The Space Station will provide a platform for man to better understand not only the universe and his planet, but also himself and the consequences of his actions. Nature and science are not two inimical spheres. Indeed, science is the study of nature and technology is but man's attempt to control the forces of nature for what will hopefully always be the betterment of mankind. Perhaps we will one day achieve a world in which nature, technology, and man all coexist in a mutually supporting ecology. Perhaps one day we will be "all watched over by machines of loving grace." The Space Station can be one of those machines.

"We shall not cease from exploration...
(and shall) get back to where we started...
and know the place for the first time."

T.S. Eliot





SECONDARY GLOSSARY

by Kathy Beauford and Frank Sietzen, Jr.

aeroponics
growing plants in a nutrient mist instead of soil.

aesthetics
a subset of axiology, that area of philosophical inquiry which explores the nature of beauty and art, etc.

aquaculture
the farming of fish and other water environment creatures, etc.

attitude
the position of the Space Station or of a spacecraft. Example: The Space Shuttle flying with its back facing the direction of flight and its cargo bay facing the Earth.

axiology
that area of philosophical inquiry which investigates the nature of values and value systems. Divided into ethics and aesthetics.

cislunar space
the space between the Earth and moon.

contextual
referring to the relationship of something to its milieu on all levels, ranging from the ecological sphere to the sphere of meaning.

cybernetic
a word referring to the interaction of biological and artificial (computer driven) systems.

distillation
the process of heating water until it changes to steam and then condensing that steam back into water. This process can be used to separate other materials from water.

dystopian
anti-utopian, negative, threatening. A negative view of the future.

electrolysis
the process of splitting water into its components, hydrogen and oxygen.

empirical
in this context, referring to the observable and measurable.

environment
all things, living or non-living, which impinge upon an organism.

epistemology
the study of knowledge and how it is obtained. That philosophical area of inquiry which answers the questions "What is truth? What is true?" and "How may truth or knowledge be obtained?"

equatorial orbit
an orbit about (around) the plane of the equator.

esprit de corps
a feeling of unity arising from common interests and experiences.

ethics
a subset of axiology, that area of philosophical inquiry which investigates the nature of moral conduct in human affairs. That area of inquiry which answers the questions "What is moral?" and "What is moral behavior?"

European Space Agency (ESA)
Europe's "NASA" which combines the efforts of the following 10 European countries: Germany, France, Spain, Italy, United Kingdom, The Netherlands, Austria, Belgium, Denmark, and Switzerland.

extra vehicular activity (EVA)
moving about outside of a spaceship, space station, or planet; a spacewalk.

fuel cell
an apparatus which combines water and oxygen to produce electricity with water as a by-product.

g
symbol of one Earth gravity.

geosynchronous orbit
an equatorial, circular orbit approximately 22,335 miles above the center of the Earth in the plane of the equator. An object in such an orbit would appear to be stationary with regard to the Earth's surface. An object in such an orbit moves at 6,875 mph. Also known as a synodic orbit.

geotropism
referring to the effects of gravity.

hydroponics
the use of water and nutrients as the growth medium for plants. Growth of plants without soil.

logistics
in this context, the movement and manipulation of materials, components, supplies, and personnel to and from the Space Station.

low earth orbit
an orbit several hundred miles above the Earth; this orbit is most commonly serviced by 2-stage rockets and the Space Shuttle orbiter.

manned maneuvering unit (MMU)
the jet-thruster backpack made by Martin Marietta and used by astronauts to move freely in space.

nodes
units that connect the various modules and components of the Space Station.

ontology
a philosophical area of inquiry which asks the questions "What is reality?" and "What is real?" Ontology concerns itself with the nature of reality.

orbit
in space, the path of a body around an axis such as the center of a planet.

orbital decay
the tendency of atmospheric drag to slow down the speed of a body in a low Earth orbit, eventually causing it to re-enter the atmosphere unless its orbit is corrected.

orbital maneuvering vehicle (OMV)
a Space Station-based unmanned spacecraft that will transport payloads, equipment, and supplies in the vicinity of the Space Station.

orbital transfer vehicle (OTV)
an unmanned rocket that will transport assembled spacecraft and booster stages from the Space Station to other destinations and orbits, and then return to the Space Station either empty or with cargo.

ph level
a quantitative measurement of the amount of acidity in something.

phase change technology
referring to a change in the physical state of a solid, liquid, or gas.

photovoltaic
solar cells which collect the energy of the sun and use it to drive electricity-producing machines such as turbines.

pitch
from a stationary position, the up and down movement of the nose or tail of a spacecraft or Space Station or orbiting body.

polar orbit
an orbit which passes over both the North and South Poles. An unmanned platform will be placed in a polar orbit.

reaction control system (RCS)
an arrangement of thrusters that move an object in space. The Space Station will have several reaction control systems so that its orbit can be adjusted.

roll
from a stationary position, the clockwise or counter clockwise rotation of a spacecraft around its axis.

siderial orbit
a method of measuring an orbit based on the position of the stars. Once around and back to one's point of origin—one period of rotation, regardless of one's relationship to a reference point on Earth.

space transportation system (STS)
the Space Shuttle and its array of components and payloads.

synodic orbit
see geosynchronous orbit.

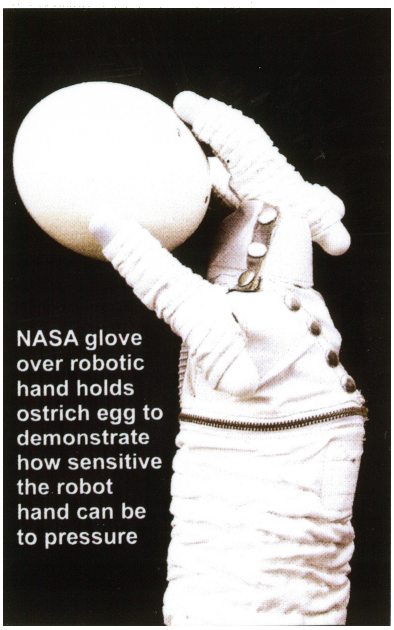
translation
refers to a change in position in space from one area to another. See pitch, roll, and yaw.

truss
the lattice-work assembly that forms the structural backbone of the Space Station architecture.

umbra
the shadow, for example, of the Earth

utopian
in this context, the ideal.

yaw
from a stationary position, the sideways movement of a spacecraft or other body.


NASA glove over robotic hand holds ostrich egg to demonstrate how sensitive the robot hand can be to pressure

Astronaut Stott

ENDNOTES

[1] The Wizard of Oz, Metro-Goldyn-Mayer Pictures, 1939. With Judy Garland, Ray Bolger, Bert Lahr and Jack Haley. Directed by Victor Fleming.

[2] Alexander Joseph, Paul F. Brandwein, Evelyn Morholt, Harvey Pollack and Joseph F. Castka, *Teaching High School Science: A Sourcebook for the Physical Sciences.* (New York: Harcourt, Brace, and World, Inc., 1961, p.132-133.

[3] Joseph, p. 132-134.

[4] Evelyn Morholt, Paul Brandwein, and Alexander Joseph, *A Sourcebook for the Biological Sciences.* (New York: Harcourt, Brace, and World, Inc., 1966), p. 169.

[5] Joseph, p. 30.

[6] Joseph, p. 30.

[7] Joseph, p. 29.

[8] Robert Haynes, *Space Shuttle Food Systems.* (Washington, D.C.: Government Printing Office, 1986), p. 14.

[9] Bernice Kastner, PhD., *Space Mathematics: A Resource for Secondary School Teachers.* (Washington, D.C.: Government Printing Office, 1985), p.72.

[10] Morholt, p. 301-302.

[11] J.V. Hunter and J.E. Barr, *Red Swamp Crawfish: Biology and Exploitation.* (Baton Rouge, Louisiana: Louisiana State University, 1984).

[12] Thomas Decair, *Teacher In Space Project.* (Washington, D.C.: Government Printing Office, 1985), p 15.

[13] The National Wildlife Federation, *The Class Project: Conservation Learning Activities for Science and Social Studies.* (Washington, D.C.: The National Wildlife Federation, 1982), p. 25.

[14] The National Wildlife Federation, p. 25.

[15] The National Wildlife Federation, p. 27.

[16] The National Wildlife Federation, pp. 29 and 30.

[17] National Aeronautics and Space Administration, *Astrophysics Utilization of the Space Station.* (Washington, D.C.:Government Printing Office, 1986) Vol .1 p 3.

[18] Glen M. Hymel, PhD., *Philosophy of Education: Instruction Manual.* (New Orleans, Louisiana: Loyola University of the South, 1979), p 16.

[19] Hymel, p. 11.

[20] Hymel, p. 26.

[21] Hymel, p. 11.

[22] Hymel, p. 11.

[23] Hymel, p. 26.

[24] Hymel, p. 11.

[25] Hymel, p. 11.

[26] Hymel, p. 11.

[27] Hymel, p. 26.

SPACE STATION FACTS AND FIGURES FROM NASA:

The International Space Station marked its 10th anniversary of continuous human occupation on Nov. 2, 2010. Since Expedition 1, which launched Oct. 31, 2000, and docked Nov. 2, the space station has been visited by 202 individuals.

At the time of the anniversary, the station's odometer read more than 1.5 billion statute miles (the equivalent of eight round trips to the Sun), over the course of 57,361 orbits around the Earth.

As of August 2011, there have been 135 launches to the space station since the launch of the first module, Zarya, at 1:40 a.m. EST on Nov. 20, 1998: 74 Russian vehicles, 37 space shuttles, two European and two Japanese vehicles. The final space shuttle mission July 8-21 by Atlantis delivered 4 1/2 tons of supplies in the Raffaello logistics module.

A total of 161 spacewalks have been conducted in support of space station assembly totaling more than 1,015 hours.

The space station, including its large solar arrays, spans the area of a U.S. football field, including the end zones, and weighs 861,804 pounds, not including visiting vehicles. The complex now has more livable room than a conventional five-bedroom house, and has two bathrooms, a gymnasium and a 360-degree bay window.

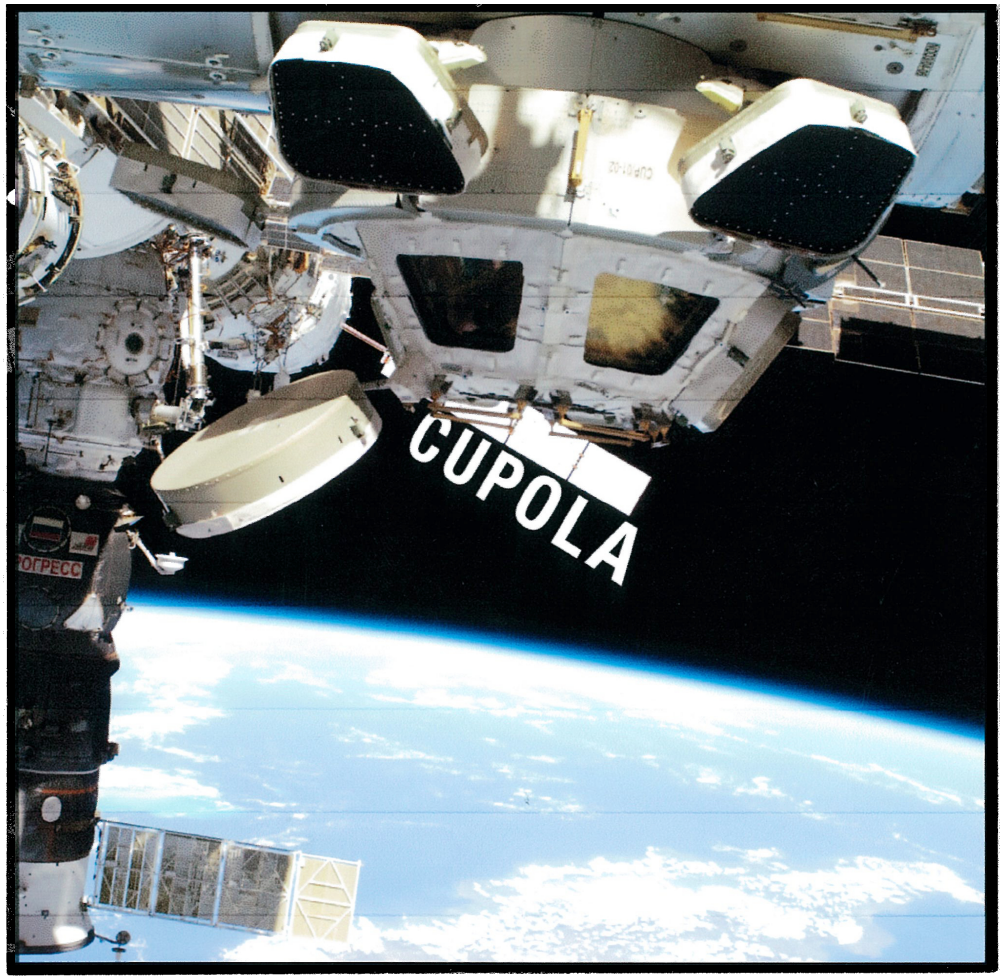
Additional launches will continue to augment these facts and figures, so check back here for the latest.

International Space Station Size & Mass:

- Module Length: 167.3 feet (51 meters)
- Truss Length: 357.5 feet (109 meters)
- Solar Array Length: 239.4 feet (73 meters)
- Mass: 861,804 lb (390,908 kilograms)
- Habitable Volume: 13,696 cubic feet (388 cubic meters)
- Pressurized Volume: 32,333 cubic feet (916 cubic meters)
- Power Generation: 8 solar arrays = 84 kilowatts
- Lines of Computer Code: approximately 2.3 million
  The ISS solar array surface area could cover the U.S. Senate Chamber three times over.
    - ISS eventually will be larger than a five-bedroom house.
    - ISS will have an internal pressurized volume of 33,023 cubic feet, or equal that of a Boeing 747.
    - The solar array wingspan (240 ft) is longer than that of a Boeing 777 200/300 model, which is 212 ft.
    - Fifty-two computers will control the systems on the ISS.
    - More than 115 space flights will have been conducted on five different types of launch vehicles over the course of the station's construction.
    - More than 100 telephone-booth sized rack facilities can be in the ISS for operating the spacecraft systems and research experiments
    - The ISS is almost four times as large as the Russian space station Mir,

and about five times as large as the U.S. Skylab.

- The ISS will weigh almost one million pounds (925,627 lbs). That's the equivalent of more than 320 automobiles.
- The ISS measures 357 feet end-to-end. That's equivalent to the length of a football field including the end zones (well, almost – a football field is 360 feet).
- 3.3 million lines of software code on the ground supports 1.8 million lines of flight software code.
- 8 miles of wire connects the electrical power system.
- In the International Space Station's U.S. segment alone, 1.5 million lines of flight software code will run on 44 computers communicating via 100 data networks transferring 400,000 signals (e.g. pressure or temperature measurements, valve positions, etc.).
- The ISS will manage 20 times as many signals as the Space Shuttle.
- Main U.S. control computers have 1.5 gigabytes of total main hard drive storage in U.S. segment compared to modern PCs, which have ~500 gigabyte hard drives.
- The entire 55-foot robot arm assembly is capable of lifting 220,000 pounds, which is the weight of a Space Shuttle orbiter.
- The 75 to 90 kilowatts of power for the ISS is supplied by an acre of solar panels.



SPACE STATION RESEARCH:

Biology and Biotechnology In microgravity, controls on the directionality and geometry of cell and tissue growth can be dramatically different to those on Earth. Various experiments have used the culture of cells, tissues and small organisms on orbit as a tool to increase our understanding of biological processes in microgravity.

Earth and Space Science The presence of the space station in low-Earth orbit provides a unique vantage point for collecting Earth and space science data. From an average altitude of about 400 km, details in such features as glaciers, agricultural fields, cities, and coral reefs taken from the ISS can be layered with other sources of data, such as orbiting satellites, to compile the most comprehensive information available.

Educational Activities The space station provides a unique platform for inspiring students to excel in mathematics and science. Station educational activities have had a positive impact on thousands of students by involving them in station research, and by using the station to teach them the science and engineering that are behind space exploration

Human Research The space station is being used to study the risks to human health that are inherent in space exploration. Focal research questions address the mechanisms of the risks and develop test countermeasures to reduce these risks. Research on space station addresses the major risks to human health from residence in a long-duration microgravity environment. Results from this research are key enablers for future long-duration missions beyond low Earth orbit.

Physical Sciences The space station provides the only place to study long-term physical effects in the absence of gravity. This unique microgravity environment allows different physical properties to dominate systems, and these have been harnessed for a wide variety of physical sciences.

TechnologyStudies on the space station can test a variety of technologies, systems, and materials that will be needed for future long-duration exploration missions.

SPACE STATION WEBSITES FOR RESEARCH FOR STUDENTS:

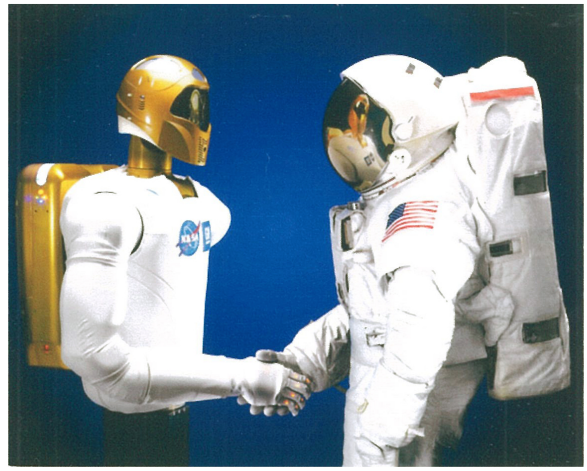
ELEMENTARY:
http://www.nasa.gov/audience/forkids/kidsclub/flash/index.html
http://solarsystem.nasa.gov/kids/index.cfm
http://spaceplace.nasa.gov/
http://www.nasa.gov/audience/forstudents/index.html
http://spaceplace.nasa.gov/

SECONDARY:
http://www.nasa.gov/mission_pages/station/research/experiments/Education.html

FOR EDUCATORS:
http://search.nasa.gov/search/edFilterSearch.jsp?empty=true
http://www.nasa.gov/mission_pages/station/research/research_teacher.html

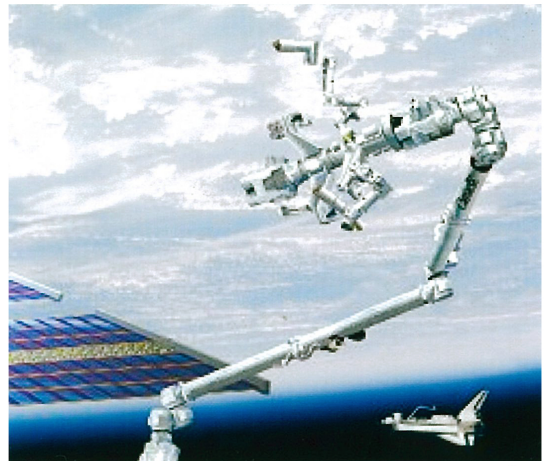
SEE ALSO THE WEBSITES PAGE

ROBOTICS ON THE SPACE STATION



Robonaut 2 shakes hands with an Astronaut. Robonaut 2 will eventually help space-walking astronauts with jobs outside the Space Station. It can also be configured for use on a planet or an asteroid, mounted on wheels. Its arms hold 20 pounds and are 2 feet 8 inches long, giving it a wing-span of 8 feet and 7 degrees of freedom. Its head moves left, right, up and down. Its hands grasp 5 pounds, and have 12 degrees of freedom in its motorized joints: 4 in the thumb, 3 in the index and middle fingers, and one in the ring and pinky fingers. Robonaut 2 was flown to the Space Station on STS-133 by Civil Air Patrol pilot astronaut Eric Boe.

Canadarm 1 is the Remote Manipulator System mounted on the space shuttle. Its arm length is 17.6 meters (50 feet 3 inches) and it is 15 inches in diameter. It has 6 degrees of freedom (similar to a human arm) and motorized joints. The shoulder has 2 joints, the elbow 1 joint, and the wrists 3 joints . It can deploy and retrieve payloads weighing up to 65,000 pounds.



Canadarm 2 The Mobile Servicing System arm can travel the entire length of the Space Station on the Mobile Base System on rails. It reaches 3.5 meters (11.48 feet). The arm has 7 degrees of freedom. Much like a human arm, the motorized shoulder has 3 joints, the elbow 1 joint, the wrists 3 joints. The arm rotates 540 degrees. (See page 22.)

http://robotics.nasa.gov/

http://www.nasa.gov/audience/foreducators/robotics/home/index.html

http://www.nasa.gov/offices/education/programs/descriptions/Robotics_Academy.html

http://www.nasa.gov/multimedia/videogallery/index.html?media_id=24196621

http://www.redstickrobotics.org

NASA WEBSITES:

NASA's Web site:
http://www.nasa.gov/education

NASA's Educator Resource Center (ERC):
http://www.nasa.gov/education/ercn

Purchase materials from NASA CORE:
http://nasa.gov/education/core

NASA teaching materials:
http://www.nasa.gov/education/materials

NASA e-mail EXPRESS mailing list:
http://nasa.gov/education/express

NASA home:
http://www.nasa.gov/home/index.html
(go to MISSIONS and International Space Station)

http://www.nasa.gov/topics/earth/ features/ 2012.html

http://www.nasa.gov/multimedia/ imagegallery/ index.html

http://www.jpl.nasa.gov/spaceimages/

NASA A-Z LISTS OF TOPICS FOR ED:

Educators:
http://www.nasa.gov/education/edu_AZ

Students 9-12:
http://nasa.gov/education/stu912_AZ

Students K-8: http://www.nasa.gov/ education/stuK8_AZ

Themed Collections of Online Resources:
http://www.nasa.gov/audience/foreducators /topnav/schedule/extrathemes/index.html

SPACE STATION WEBSITES:

Space station 2012 calendar download:
http://www.nasa.gov/pdf/615398main_ 2012_iss_calendar.PDF

http://www.nasa.gov/mission_pages/ station/main/index.html

http://www.nasa.gov/mission_pages/ station/structure/index.html

http:www.nasa.gov/multimedia/video gallery/index.html?media_id=11234781/

AEROSPACE EDUCATION WEBSITES:

http://GoCivilAirPatrol.com

http://www.aviationeducation.org

National Science Teacher's Assoc:
http://www.nsta.org

http://teachspacescience.org/cgi-bin/ssrtop.plex

http:spacecraft kits.com/free.html

http://mynasadata.larc.nasa.gov

http://explorerschools.nasa.gov

NASA MULTIMEDIA:

NASA Do-it-Yourself Podcast:
http://www.nasa.gov/education/diypodcast

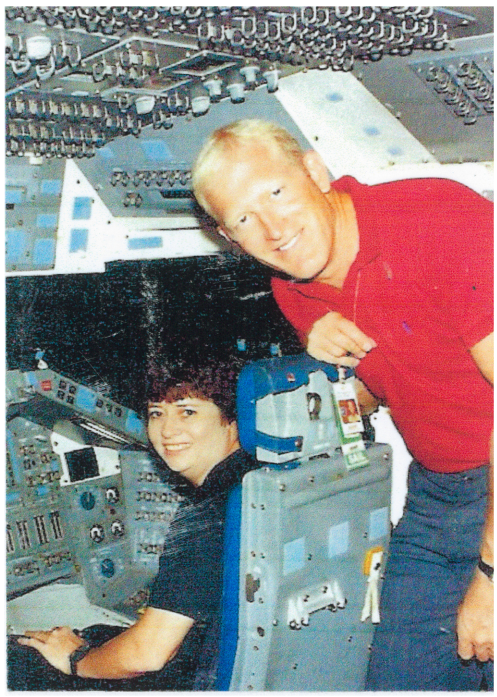
NASA eClips (Video Learning Clips):
http://www.nasa.gov/education/nasaeclips

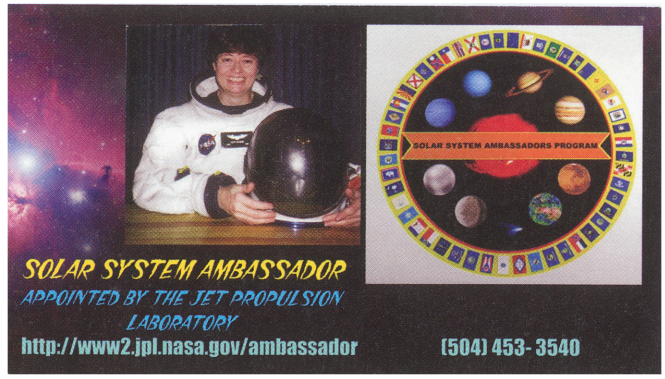
NASA Education TV Schedule:
http://www.nasa.gov/education/tvschedule

NASA Digital Learning Network (Webcasts):
http://www.nasa.gov./education/dln

Image Galleries:
http://www.nasa.gov/education/galleries

Lt. Colonel Kathy Beauford is state Director of Internal Aerospace Education for Civil Air Patrol and a navigator for air search and rescue for The U.S. Air Force Auxiliary. Kathy is also a Solar System Ambassador, appointed by NASA's Jet Propulsion Laboratory. Kathy holds a Master in Aerospace Education in the Civil Air Patrol and a Master's Degree from Loyola University of the South. She is certified in Computer Literacy and English and is Robotics Project Manager for La. Wing. Kathy has received the prestigious Frank Brewer Aerospace Award, naming her as one of the top eight aerospace educators in the country. Kathy has won 7 education awards and 26 aerospace education awards. Kathy's favorite award was the Sigma XI Scientific Society Award of Recognition "for dedication in the teaching of science." She said, "I was thrilled to be recognized by scientists." At the LNSC, Kathy founded the Space Education Institute. Kathy was a participant in the Teacher in Space Program but was not chosen as an astronaut. Below, Kathy with astronaut Sam Geymar in the space shuttle simulator at Johnson Space Center. She says, "America needs ***SPACE*** to ***GROW*** ! "





Lynn Purnell Hagan, a native of Houson, Texas, received her B.A. in anthropology from Texas A & M University in 1977. After becoming Curator of Displays for the Confederate Museum of Richmond, Texas, she moved on to educational and consulting work with the Houston Zoological Gardens, The Audubon Park & Zoological Gardens, and the Louisiana Nature & Science Center in New Orleans, Louisiana. At LNSC, she has successfully run summer day camps relating to space, geology, anthropology and nature. Also, she has been involved in presenting science programs at area schools and various parish libraries.

Pat Bibee, an outreach educator for The La Nature & Science Center, has previously worked as a park ranger in the San Diego, California area.

Elizabeth Ann "Liz" Elsen, of Chicago, Illinois, holds a B.A. and M.S. in Special Education and an advanced Degree in Administration and Supervision.

Frank Seitzen, aerospace author, is a frequent contributor to *Space World Magazine,* the journal of the National Space Society. He contributed an article to *STS 7: First American Woman in Space* and is the planner of Space Station Day.

Captain Judith Tremblay, CAP, is Director of Internal Aerospace Education for Louisiana Wing and Group 3 Aerospace Education Officer. She is an aircrew member for Air Search and Rescue. Captain Tremblay served as proofreader for this project.

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Lockheed Martin Space Systems Company

Space is a demanding environment. But with systems built by Lockheed Martin, space is where the future takes flight, through partnerships that raise global communications, weather forecasting, space exploration and national security to new levels. Delivering vital space capabilities is all a question of how. And it is the how that makes all the difference.

Lockheed Martin Space Systems Company, a major operating unit of Lockheed Martin Corporation, comprises two primary business units: Space Systems and Michoud Operations; and two joint ventures, United Space Alliance and United Launch Alliance. Space Systems comprises several core lines of business with major facilities in Denver, Colo., Sunnyvale, Calif., and other locations.

Space Systems Company designs, develops, tests, manufactures and operates a full spectrum of advanced-technology systems for national security, civil and commercial customers. Chief products include human space flight systems; a full range of remote sensing, navigation, meteorological and communications satellites and instruments; space observatories and interplanetary spacecraft; laser radar; fleet ballistic missiles; and missile defense systems. Space Systems, with major operations in Denver, Colo., and Sunnyvale, Calif., is focused on several core lines of business: Human Space Flight, Global Communications Systems, Commercial Space, Sensing & Exploration Systems, Missile Defense Systems, Strategic Missiles, Commercial Launch Systems, Surveillance & Navigation Systems and Special Programs.

Michoud Operations based in New Orleans, LA., built the huge external fuel tanks for the Space Shuttle and currently is building the core structure for the Orion Multi Purpose Crew Vehicle, America's next deep space exploration spacecraft.

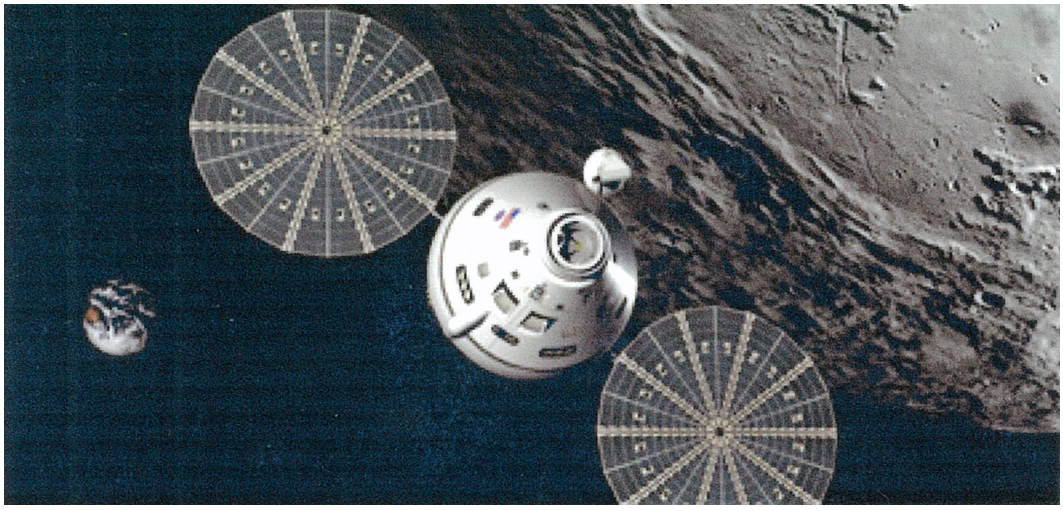
Space Systems Company's two significant joint ventures are: United Space Alliance, based in Houston, TX, a joint venture with The Boeing Company that manages the Space Shuttle program for NASA.

United Launch Alliance, based in Denver, CO., a joint venture formed by Lockheed Martin and The Boeing Company in 2006, to provide Atlas and Delta launch services for the U.S. Government, including the Department of Defense, NASA, the National Oceanic and Atmospheric Administration and the National Reconnaissance Office.

SSC Homepage on LockheedMartin.com: http://www.lockheedmartin.com/ssc/

SSC Organization: http://www-ast.ast.lmco.com/ORG/org.html

SSC Objectives: http://policy.global.lmco.com/lmssc/objectives.html



Orion orbits the moon with disc-shaped solar arrays tracking the sun to generate electricity. Image Credit: Lockheed Martin Space Systems Company.

LOUISIANA NATURE & SCIENCE CENTER

The Louisiana Nature & Science Center, Inc., is a private, non-profit, natural science museum serving the Southeastern Louisiana and greater Gulf Coast region. Located on an 86 acre woodland preserve within Joe Brown Park in Eastern New Orleans, the Nature Center is freely populated by small animals, birds, and aquatic life. The site consists of an award winning education/interpretive building featuring multi-purpose amphitheatre, changing hands-on exhibits and educational programming, and handicapped accessible nature trails, wetlands, and ponds areas. Dedicated to the realization that people of Louisiana inhabit a truly unique part of the Earth where the unrivaled combination of natural beauty and teeming life abound in native wetlands, waters and on the land, the LNSC celebrates the relationship and inter-dependence of man and his natural world. Nowhere else do people of an area live so closely with abounding life, incorporate it into their culture, depend on it for their food, and rely on it for their livelihood.

MISSION

The mission of the La Nature & Science Center is manifold:

1. *To Heighten An Awareness* of man's place in the natural world and of the interdependence of all living things with the ecosystem; to foster a greater understanding of the science of nature and of the nature of science; and, to encourage an appreciation for the beauties and values of the natural world.

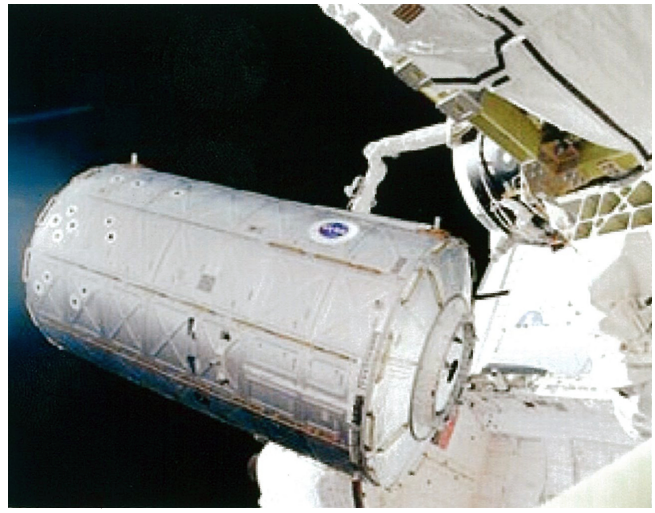
2. *To stress Education* as the primary means of bringing people to a better understanding of their natural environment; to *Demonstrate Ways* in which to live in harmony with nature through education exhibits, programs, and activities which focus on the natural sciences, natural history, information, and resource conservation; *To Provide Programs for Learning* for people of all ages and *To Present Criteria* from which sound environmental choices can be made which affect the future.

3. *To Inspire* in people of all ages a sense of stewardship for the natural world and an understanding of how, through cause and effect, what we do now affects the world that future generations will inherit.

4. *To Be A Resource* of natural science information for the layman; to be available to the community to answer inquiries and offer direction; to cooperate with universities, colleges, and area schools in furthering natural science information.

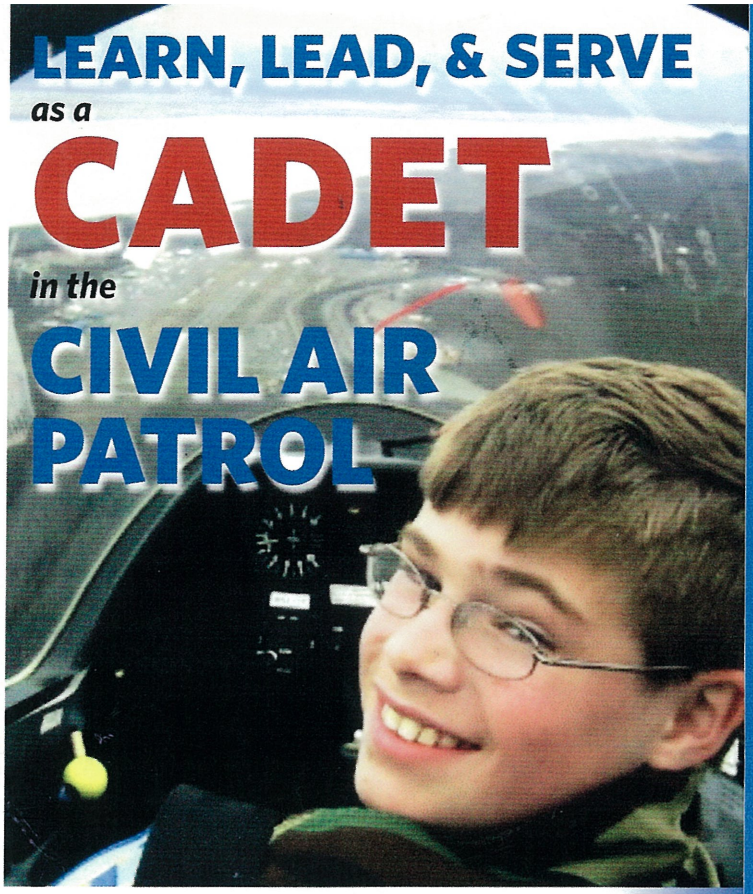
5. *To Stimulate* a love of learning through discovery and a growing curiosity in the world around us through creative exhibits and flexible programming: *To Provide Recreational Activities* to visitors through programs both on and off site; to make learning fun!

In 1994, the Louisiana Nature & Science Center merged with the Audubon Institute. It was destroyed by Hurricane Katrina. The Audubon Institute is considering re-configuring the Louisiana Nature & Science Center.



The U.S. Laboratory Module Destiny

LEARN, LEAD, & SERVE as a CADET in the CIVIL AIR PATROL



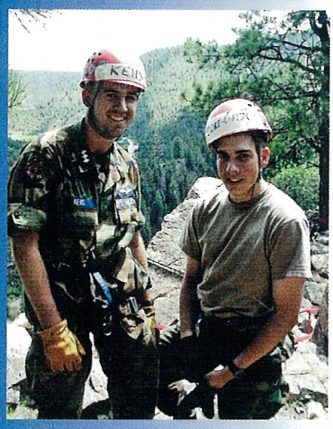
Do you want to fly? Do you want to honor and serve America? Then rise to the challenge of cadet membership in the U.S. Air Force Auxiliary, Civil Air Patrol.

You'll find cadet life exciting if you enjoy:

- Flying
- Leadership Training
- Obstacle Courses
- Model Rocketry
- Teambuilding
- Hiking & Camping
- Earning Rank & Awards
- Search & Rescue
- Exploring Aviation Careers
- Making Friends

CIVIL AIR PATROL

GoCivilAirPatrol.com



Questions?

How old do I have to be? You must be at least 12 but not yet 19 to join as a cadet. CAP also offers opportunities for adults.

How much time do I have to commit? On average, cadets meet one night a week for 2 hours and enjoy special events one Saturday each month. In summer, you can attend a week-long camp.

How much does it cost? Annual dues and uniform expenses will total about $100. Other fees may be required for weekend and summer events.

Are cadets required to join the military? As a cadet, you are never obligated to join the military, but 10% of all Air Force Academy cadets got their start in CAP.

Who supervises the cadets? Adult volunteers, fingerprinted and screened by the FBI, chaperone all cadet activities.

Benefits of Cadet Life:

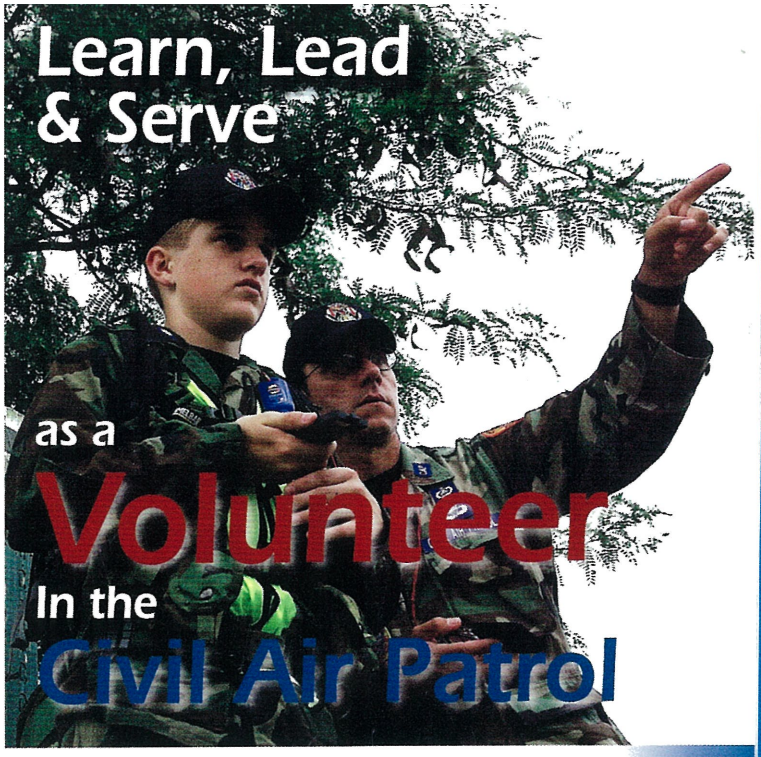
- Develop leadership skills
- Test-fly potential careers
- Solidify your moral values
- Succeed in school

En Espanol: *Guia Para Padres*
capmembers.com/padres

Cadets are allowed to certify for and participate in actual search and rescue ground teams.

UNITED STATES AIR FORCE AUXILIARY
CIVIL AIR PATROL

Learn, Lead & Serve



as a

Volunteer

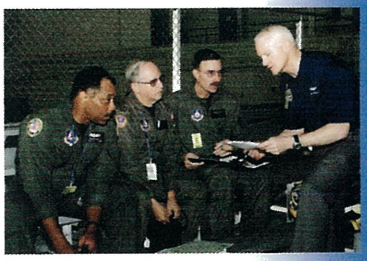
In the

Civil Air Patrol

Are you looking for a way to make a difference in your community? Do you want to honor and serve America? Then become a volunteer in the U.S. Air Force Auxiliary, Civil Air Patrol.

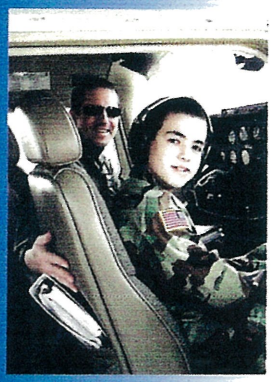
When you join the ranks of more than 56,000 CAP volunteer members, you may participate in a variety of activities:

- General aviation search and rescue
- Mentor youth in our cadet program
- Join other federal and nonprofit organizations to provide disaster relief
- Help local educators teach students about aerospace education
- Support CAP's communications network, one of the most extensive in the nation
- And much more....



CIVIL AIR PATROL

GoCivilAirPatrol.com



Questions?

How much does it cost? Annual membership dues vary by state, but average about $60. You will also be responsible for any required uniform items.

What's the time commitment? On average, members meet one night a week for 2 hours. You will also have the opportunity to attend additional training, conferences and other activities.

Do I have to wear a uniform? CAP members have the privilege of wearing a uniform. The local unit will give you more information about the types of uniforms, both military and civilian, that are available.

I'm not a pilot, is there a place for me in CAP? Absolutely! Pilots are one of our most visible positions in CAP, but most volunteer members do not fly. Youth development, aerospace education, or public relations are just a few areas that you may be interested in. For more information, contact your local unit.

Am I considered a member of the military? No, as a CAP volunteer member, you are a civilian and under no obligation to any branch of the military.

Benefits of being a CAP volunteer:

- Serve your community and your country
- Develop and enhance your leadership skills
- Provide a positive influence on today's youth
- Enjoy the camaraderie and fellowship of other volunteers

To learn more, contact us as shown below or visit GoCivilAirPatrol.com

Civil Air Patrol was established by Act of Congress as the official auxiliary of the U.S. Air Force to serve the nation through:

Aerospace Education
Emergency Services/ Search and Rescue &
Cadet Programs

Solar System Ambassadors (SSA) are trained volunteers who share information about NASA's space missions with people in their local communities. There are 523 Solar System Ambassadors in 50 states, Puerto Rico, Guam and the District of Columbia, with additional Ambassadors currently living in the Netherlands, Kenya and Afghanistan conducting programs for local audiences. Annually, Ambassadors reach about one-half million people in direct contact events and many more via media outlets (radio, television, publications, social media). This effective informal education/public outreach program is run by NASA's Jet Propulsion Laboratory. To contact an SSA volunteer, please visit the website at: http://www2.jpl.nasa.gov/ambassador/

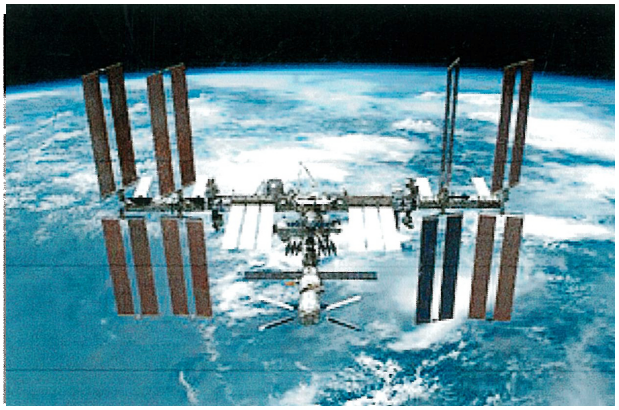
RED STICK ROBOTICS

Providing Professional Development Activities and Resources for Hands-on and Authentic Learning in the Classroom

- Instructs interactive courses for teachers and students that relate vital Science, Technology, Engineering, and Mathematical (STEM) concepts to real-life learning
- Integrates Standards-Based Robotics into the curriculum
- Encourages more students to pursue STEM-related degrees

For more information, please contact Gina Payne - gina@redstickrobotics.org

International Space Station



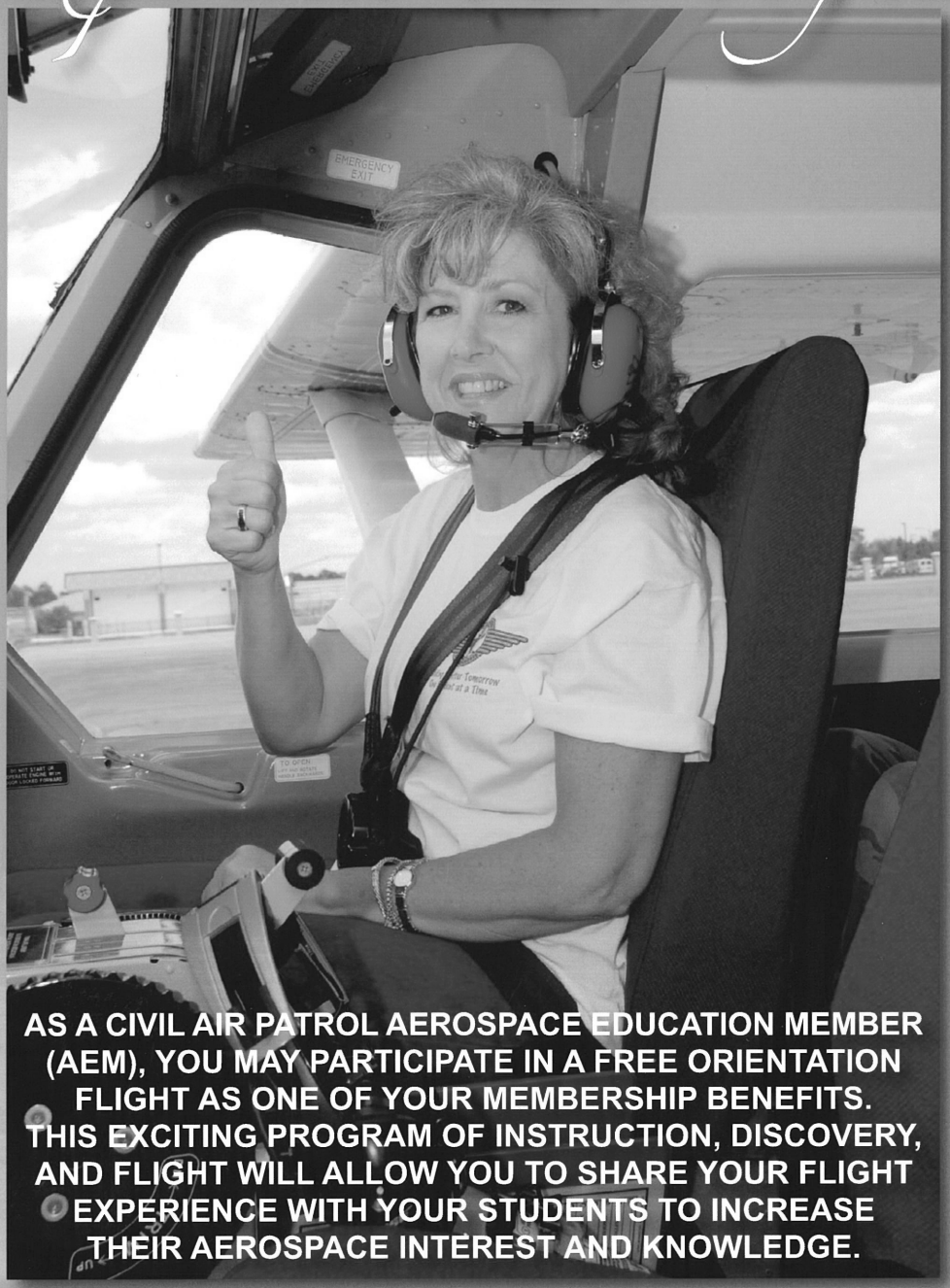
The International Space Station on 29 May 2011 as seen from the departing Space Shuttle *Endeavour* during STS-134

Notes

Notes

CAP EDUCATORS!

Experience TOP Flights



AS A CIVIL AIR PATROL AEROSPACE EDUCATION MEMBER (AEM), YOU MAY PARTICIPATE IN A FREE ORIENTATION FLIGHT AS ONE OF YOUR MEMBERSHIP BENEFITS. THIS EXCITING PROGRAM OF INSTRUCTION, DISCOVERY, AND FLIGHT WILL ALLOW YOU TO SHARE YOUR FLIGHT EXPERIENCE WITH YOUR STUDENTS TO INCREASE THEIR AEROSPACE INTEREST AND KNOWLEDGE.

To arrange your Teacher Orientation Program Flights, please contact Judy Stone at jstone@capnhq.gov. Judy will then locate the coordinator in your state and that person will contact you for a time and location for your flight. But...it is more fun to fly with a friend! Encourage one of your peers to join CAP with you and you can fly together. The BEST experience is with several members of your school or school system joining together and planning a fun-filled TOP Flights Day! All participants must be CAP members. For more information, please go to our website at www.capmembers.com/ae.

One giant step for mankind begins with one small step —

Join Civil Air Patrol

That's what NASA astronaut and former Georgia wing cadet Eric Boe did

From dreaming about the shuttle as a CAP cadet, Boe piloted the real thing in 2008.