Earth Science

LEARNING OBJECTIVES:
Students will be acquainted with the dynamic systems that support life on Earth. They will have an appreciation for the position of Earth in the universe. They will be exposed to the basic components of the Earth with emphasis on the biosphere. They will be able to relate basic human needs to Earth processes and articulate them in term of requirements for supporting life on a space transporter.

DISCUSSION:
The Hubbell Space Telescope allows us to view galaxies 12 billion light years from Earth (Slide 1). This is as far as we can see into the universe. There may be many more galaxies beyond these. Among these billions and billions of stars and planets there are many possibilities for life out there. Today we will discuss what is required to support life as we know it here on Earth. The Earth is located in the Milky Way Galaxy similar to the Andromeda Galaxy (Slide 2) shown here. There are at least 200 billion stars in the Milky Way, many are believed to have planets. Perhaps there is other life within our own galaxy. This is approximately where our star, the sun is located.

Getting closer to home, this is the Solar System (Slide 3) with our star, the sun, in the center. Nine planets and numerous satellites, asteroids, comets, and other stuff circle the sun. Is there life in our solar system? Of course there is. We are alive here on Earth (Slide 4). Some of the other planets, particularly Mars, may have had some form of life at one time.

Water has been discovered on Europa, a satellite of Jupiter. Europa is about the size of out moon. All of you campers are assigned to go explore Europa to determine if there is life there. It will take about two years for your space transporter to get to Europa. You will be on the ground, which is probably a thick layer of ice, for about three weeks. Returning to Earth will take another two years. Today's assignment is to write a list of requirements for the engineers who will design the transporter. You will be spending four years on the transporter. What will you need to take along? Let's answer that question by looking at what we need to support life here on Earth.

Let's make a list (on the white-board) of the things required to support life.

radiation shield
oxygen
atmospheric pressure
water
food
plants
animals
materials
energy sources
sunlight
fossil fuels
geothermal
water power
minerals
entertainment
gravity
clothing and shelter

In this image of the Earth we can see the land and water. Above the surface of the Earth we have the atmosphere. Above that we have the magnetosphere. The magnetosphere is a layer of charged particles that shields the earth from harmful radiation coming from the sun and outer space. Without this shield, plants and animals such as could not survive. So on our space transporter, we will need a shield of some sort to protect us from cosmic radiation.

The atmosphere is made up of several gases. While we must have oxygen to breathe, it only makes up 21 percent of the atmosphere. Nitrogen is the predominant gas occupying about 78 percent of the atmosphere. The remaining one percent of the atmosphere is made up of such gases as argon, neon helium, krypton, and hydrogen. When we breathe, we inhale oxygen and exhale carbon dioxide. On our transporter, we will need to carry an awful lot of oxygen or find some way to convert carbon dioxide back into oxygen or we would smother. How is carbon dioxide converted to oxygen here on Earth? The plants do that for us using a process called photosynthesis. Maybe we should suggest taking some plants along to the transporter engineers. While we are conscious of the fact that we need oxygen, the atmosphere provides something else that is vital to our survival. That is atmospheric pressure. Without atmospheric pressure, we would literally explode and we wouldn't want that to happen. We are most comfortable with a pressure of 10 to 15 pounds per square inch. Thus we can live at sea level or in the mountains. Let's tell the engineers that we need to keep the transporter pressurized to about 12 pounds per square inch so we can live in a shirt sleeve environment instead of wearing our astronaut suits all the time. That will make it easier to eat, scratch and go to the bathroom.

The surface of the Earth is divided into land and water. The water predominates in the form of seas and oceans making up approximately 70 percent of the surface. Like oxygen, water is vital for sustaining human life. But, not just any water, we need fairly clean water free of salt and polluting chemicals. Let's look at how we get "clean" water. This diagram (Slide 5) is known as the water cycle that many of you are already familiar with. Basically, the water is heated by the sunlight and it evaporates (turns into water vapor) and goes into the atmosphere. Water

vapor also comes from plants in their transpiration process and from animals like us when we breathe and sweat (which is all the time). As the warm moist air rises, it cools forming clouds. When the water droplets get large enough they fall to earth in the form of rain, snow, or occasionally as chunks of ice that we call hail. This process of evaporation followed by precipitation is the primary source of our fresh water that we drink and bathe in. The rain and melted snow forms our streams and lakes. Some of the water seeps into the ground while plants and animals absorb some almost immediately. The water gets mixed with salt and other things as it makes its way to the oceans where it evaporates repeating the cycle that has been continuing for millions of years. Let's hope it continues for many more years. The transporter is too small to make it rain inside, but we can design a system that evaporates the water from our waste products and condenses it into liquid water for drinking and bathing.

We all like to eat and that is a good thing since food is necessary for sustaining life. Our food on Earth comes from plants and animals supplemented with minerals such as iron, copper, zinc, and many others. Plants have been around for millions of years. Animals evolved to eat the plants and later to eat each other. Just like us, plants and animals share many of our basic needs. Since we told the transporter engineers that we wanted to take plants along to change carbon dioxide into oxygen. Animals change oxygen into carbon dioxide, let's tell them to make sure that the plants are edible. Well the plants need to grow too, so they need nourishment. On Earth, the plants get their nutrients form the soil. Soil is made up of minerals and organic matter such as rotted plants and animals and animal waste. Since we will be making plenty of waste on our trip, let's tell the engineers that we need a system that sterilizes our waste and feeds it to the plants. Clothing and shelter are basic needs as well. The importance of these varies with the climate we live in. Clothes protect us from getting sunburned by blocking the sun's ultraviolet rays. They protect us from the cold, rain, and snow. Of course, if we have the right kind of shelter, we have less need for clothing. So where do clothing and shelter come from? Until recently, clothing came from plants and animals. Now clothes are made out of materials derived from petroleum. Our shelter primarily comes from plants in the form of wood and from the ground in the form of stone, concrete, and glass. In the past some people used animal skins and even snow and ice to build shelters. Today plastics are used for building materials and many other things as well. In fact all of the materials we use come from the earth directly or indirectly. Making clothes during our trip would be quite a bother. Let's tell the engineers that we need a Hawaiian like climate so we don't need to wear many clothes.

Keeping our transporter at a comfortable temperature will require energy for heating and cooling depending on haw far we are from the sun. We get our energy here on Earth from a number of sources. Coal and oil, known as fossil fuels, were formed millions of years ago from lush vegetation that was buried and became solidified under pressure. Originally the plants that were transformed into coal and oil received their energy from the sun. Sunlight warms us today and is the primary cause of our weather and climate. Radioactive decay causes the interior of the earth to be hot and in some places we can tap into this as a geothermal energy source. While the sun operates on nuclear energy, has only recently harnessed this energy source. There are other forms of energy such as water and wind power as well. So for our transporter, we could use solar energy, but Jupiter is a lot farther from the sun, so we need to think of another energy source. let's take our own sun with us, that is a nuclear power plant.

What happens if we break down? Here on Earth we have many sources of materials. Metals like iron, copper, zinc, and aluminum are mined and refined. Metals are primarily a product of the nuclear processes that formed the Earth billions of years ago. Many other materials such as wood, glass, plastic, stones, and so forth are available too. We are very limited for space on the transporter so let's tell the engineers that we need reliable systems and plenty of spare parts. Let's see what else we need. Oh yes, what holds us all together? Well, that's gravity. Without gravity we would be in a lot of trouble. We would just all float off in different directions. Floating around in the transporter for four years without gravity will be fun at first, but the novelty will wear off. Let's have the engineers rig up a long tether between our transporter and the booster rocket that put us into space. We could create an artificial gravity by making the two rotate around each other.

There is one other item on our list. That is entertainment or to be more formal we would call it intellectual stimulation. When we are deprived of intellectual stimulation we don't do very well. In fact we tend to go crazy. Fortunately, Earth is a very entertaining place. Everything is continually changing like day into night, the weather, the seasons, and of course the social interaction with other people. Our environments are further enriched when we participate in academics, arts, and games. Make a list of the things you want to take along for entertainment. Remember that you have an excellent opportunity to study astronomy. Make sure the engineers are aware of your needs for observation equipment.

Mission Team Leader's Notes

The sample dialog above should be modified according to the interest of the Galaxy Explorers. Encourage participation by having the students explain the Earth's life support systems as well as their concepts for the space transporter. Remember that the objective here is to stimulate imaginations and interest rather than completely describing all the aspects of Earth Science.

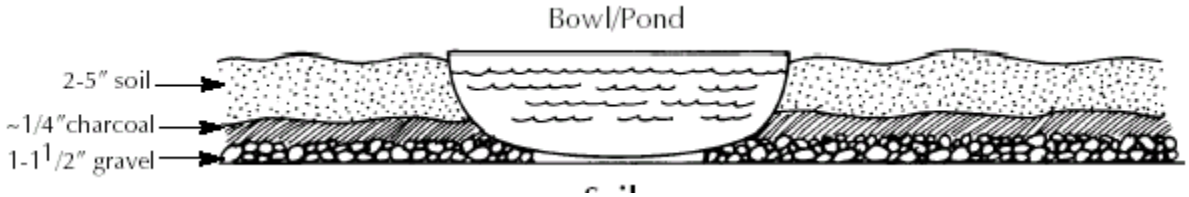
DISCUSSION QUESTIONS
1. How would your knowledge of Earth Science help you prepare for the trip?
2. Where would you like to travel to in the solar system?
3. What would you like to do when you get there?

Materials required
Computer or viewgraph projection equipment including a screen.
Preliminary list of visual aids:
Slide 1: Distant Galaxies
Slide 2: Milky Way Galaxy
Slide 3: Solar System
Slide 4: Planet Earth
Slide 5: Biosphere Diagram

ACTIVITY

Build an open biosphere. Mission Team members should build a small Earth environment to understand that the components fit together, and that they interact and change. Team members

may create a terrarium using plants. Include a pond in the terrarium. The terrarium could show land, air, water, and energy. Some mission team members may choose to pick a particular environment. One team or team member might work with sandy soil and cactuses, for example, and another might fill an aquarium with tadpoles and pond plants.
Terrarium. Potting soil, gravel, activated charcoal, sand, clay, rocks, and small plants. Rectangular glass tank, watering can with a thermometer inside. Small glass bowl to sink in the soil as a pond. Small plastic toys loaned by the students.



Field Trip
Visit a Greenhouse.
If possible on a cold sunny day, visit a local greenhouse, zoo with a jungle habitat, botanical garden, or solar-heated atrium. Mission Team members can feel what it is like to be inside a greenhouse. Have the students identify the life-supporting components. What cycles can they identify? Ask them to compare the greenhouse to their terrarium and to the whole Earth.

Additional stuff to do on their own
Use one of the terrariums or separate containers. Set up an experiment monitoring plant growth and plant appearance in which frequency of watering, water temperature, exposure to fresh air, soil, and light at the start are as constant as possible. Select plants with different light or water requirements and establish if they thrive under these starting conditions. Select rapid growing grasses or flowers and slow-growing cactuses, succulents, ferns, etc. Note their condition and measure their growth on a chart in notebooks. Later, mission team members will experiment with the terrariums by altering one of the components, either exposure to light or frequency of watering, to see how changes affect the various types of plants.