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The Last Frontier

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Astronomy has always been a favorite part of the 8th grade curriculum. Students are always eager to study this subject. Many of them are science fiction fanatics, faithfully watching shows like the X-Files, Deep Space Nine, Voyager, Babylon 5, and Space Above and Beyond. Terms used in the above shows such as zero gravity and black holes will be addressed, along with commonly used astronomical vocabulary.

In addition, it is important in the teaching of science to keep up with current events. Astronomical topics/discoveries are constantly in the news. Examples include the comet that could be seen in the night sky, the Hubble Telescope repair, and the discoveries of many new galaxies and even some planets. In the minds of students these discoveries can make young imaginations soar and fuel their search for knowledge.

A curriculum unit on Astronomy is also an excellent way to teach the scientific method. Activities that are part of this topic are a great lead into high school for the 8th graders.

Prior to this unit, it is assumed that stellar evolution and the history of the Universe have been studied. This unit will be structured in the following manner: the history of space flight, space basics (including physics), astronauts, living and working in outer space, and the possibility of life elsewhere in the Universe.

Taking off from Earth, orbiting and space travel involve a number of planetary laws/forces such as inertia and gravity. These will be discussed and their impact on space travel will be shown through demonstrations and hands-on activities.

Living and working in outer space is a integral part of space travel. Spacesuits, living quarters, food and recreation will be covered. Breathable air and waste recycling are important considerations. These will be covered in a Space Station activity.

Distance is an important, yet hard concept for students to understand. This includes the definitions of light year and astronomical unit. What is the fastest travel speed, and just how far away planets, moons, stars, etc. really are. Activities will cover these topics.

Once we land on a planet, how can we stay and live there? What supplies will we need? What kind of jobs/people are needed to sustain a space station? If people get stranded on a planet, what type of emergency supplies are necessary for survival? There are a couple of activities in this unit pertaining to the above.

The last part of this curriculum unit will cover the possibility of life elsewhere in the Universe. Students enjoy discussing this topic, which fuels their imaginations. Scientists are constantly listening and looking for signs of life outside the Earth. An activity called, "Invent an Alien" is included in the lesson plans.

All curriculum in 8th grade is preparation for high school and I address this in the lesson plans. I believe in incorporating a variety of types of activities, as students have different learning styles. Thus, labs addressing the scientific method, handson activities, open-ended lessons and writing across the curriculum are part of this unit. Opportunities are included for both individual and cooperative learning.

HISTORY OF SPACEFLIGHT

One of the first records of a device that employed the principle of rocket flight occurred around 400 B.C. Archytas (of Greece) flew a wooden pigeon, suspended on wires and propelled by escaping steam. Hero, 300 years later flew a similar device. (NASA, 1993)

The first true rockets were developed around the first century A.D. China, using a primitive form of gunpowder, invented fireworks. These were first used for religious purposes, and later on in war. (NASA, 1993) Launching a satellite into orbit was a 17th century idea. (Hartmann, Impey, 1994)

In 1898, a Russian schoolteacher, Konstantin Tsiolkovsky proposed the idea of space exploration by rockets. In 1903, he suggested the use of liquid propellents to achieve greater range. Tsiolokovsky is known as the father of modern astronautics. (NASA, 1993)

Robert H. Goddard, early in the twentieth century, further improved rocket science by coming up with the following discoveries:

- rockets work better in a vacuum.
- multistage rockets
- successful liquid-propellant rockets. (NASA, 1993)

Since Goddard's time, we have sent dozens of ships to more than seventy worlds and four spacecrafts to the stars. (Sagan, 1994) When we first started sending astronauts into outer space, a new era of science was ushered in. Yet there were those who thought that landing on the Moon was just a Hollywood stunt. (Sagan, 1994)

Why do we, why should we explore outer space? First, America is a frontier society and space, the new frontier offers the spirit of adventure. This also helps to stimulate student interest in careers in science and math. Furthermore, many nations, for example: Russia, China, Japan, France, Canada and the United States are working together to advance knowledge for the betterment of the whole world. The International Space Station, which will be discussed later on is an example of this.

Furthermore, through the development of satellite technology, weather forecasting has been greatly improved and many lives have been saved. Communications satellites have brought the people of the world closer. Maps developed from satellite images have made travel easier. (Sagan, 1994)

In addition, satellites orbiting the Earth have enabled us to study the interactions of the atmosphere, oceans, land, energy and organisms. By studying Venus, scientists have learned more about global warming and the danger of releasing ozone-depleting chemicals into the air. By studying Mars, they have learned about the dangers of a nuclear winter. All in all, spacecrafts have sent back more than four trillion bits of information or the equivalent of 100,000 volumes of encyclopedias. (Sagan, 1994)

Due to space travel, our technology is rapidly increasing. There have been numerous inventions and improvements to already existing machines and materials. Examples include: virtual reality, athletic shoes, smoke detectors, heart rate monitors, fire resistant materials, radiation insulation and studless winter tires. (NASA, 1994)

How much does space travel cost, is a question that students frequently ask. In 1969, the year of the first Moon landing, NASA received about four cents out of each dollar in the national budget. In 1991, this had been reduced to just a little over one cent. This means that the average taxpayer pays out approximately sixty-nine dollars per year, or about $5.78 per month. (NASA, 1991)

SPACE PHYSICS

In order to launch a spaceship or rocket off the ground to orbit the Earth or to travel, there are certain basic principles and laws that must be followed and understood.

Sir Isaac Newton came up with some laws that still hold true today. He was born on December 25, 1642, the same year that Galileo Galilei died. Newton’s Law of Universal Gravitation states that: the force of gravitational attraction between two point masses (m1 and m2) is proportional to the product of the masses divided by the square of the distance between them. In the following equation, G is a gravitational constant, r is the distance between the centers of the masses and F represents the force:

$$F = G \frac{m1m2}{r^2}$$

In other words, if the distance between the objects is doubled, the attraction between them is diminished by a factor of four, and if the distance is tripled, the attraction is only one-ninth as much. Due to gravity, a satellite needs more speed to stay in a lower orbit, than in a higher one. (NASA, 1994)

Newton’s First Law—An object continues in a state of rest or uniform motion unless acted on by an external force. (NASA, 1994) This is also known as the Law of Inertia. An example of this is as follows: In zero G or microgravity, like in the Space Shuttle, objects stay where put. You can leave a pen in mid-air and come back for it hours later. If an astronaut is sitting in the middle of a cabin, too far to push off a wall, they’re stuck until someone comes to push them into motion. (NASA, 1995)

Newton’s Second Law—The resultant force acting on an object is proportional to the rate of change of momentum of the object. The change of momentum being in the same direction as the force. Force= mass x acceleration. (NASA, 1995)

Newton's Third Law—To every force or action, there is an equal and opposite reaction. (NASA, 1995) An example: If you stand on a skateboard and throw a basketball, the board rolls in the direction opposite the way you throw. (The Astronomy Society of the Pacific, 1996)

Put Newton's three laws together like this: An unbalanced force must be exerted for a rocket to lift off from a launch pad or for a craft in space to change speed or direction (first law). The amount of thrust (force) produced by a rocket engine will be determined by the mass of the rocket fuel that is burned, and how fast the gas escapes the rocket (second law). The reaction, or motion of the rocket is equal to and in the opposite direction of the action, or thrust from the engine (third law). (NASA, 1995)

A bit of trivia—during a 1960 baseball game between the New York Yankees and Detroit Tigers, Mickey Mantle hit a home run out of the stadium. It is in the Guiness Book of World Records as the longest homerun ever. If Mickey Mantle had swung his bat 150 times faster, he could have hit the ball into orbit. (The Astronomy Society of the Pacific, 1996)

The Space Shuttle is able to stay in orbit because it is launched in a trajectory that arcs above the Earth, so that it is travelling at the right speed to keep it falling while maintaining a constant altitude above our surface. For instance, if the Space Shuttle climbs to a 320 kilometer high orbit, it must travel at a speed of about 27,740 km/hr. to achieve a stable orbit. At this speed and altitude, the Shuttle's falling path will be parallel to the curvature of the Earth. (NASA, 1995)

Zero gravity is a term commonly misused when people talk about space travel. The correct term is microgravity. Let's start at the surface of the Earth. Here the acceleration of an object acted upon by our gravity is 1G or 9.8 meters per second squared. If you fell off a roof that was 5 meters high, it would take you just one second to reach the ground. In 1% of Earth's gravity (microgravity), the same drop would take 10 seconds. If the microgravity environment was equal to one millionth of Earth's gravitational pull, the same drop would take 1000 seconds or about 17 minutes. (NASA, 1995)

One way to create a microgravity situation is to free fall. If you were travelling in an elevator and the cables break, both you and the elevator would be travelling at the same rate downward. Another way to create this is to travel far away from the Earth. (NASA, 1995)

Weightlessness in outer space, is another commonly misused synonym for microgravity. Microgravity results from giving a spacecraft enough forward velocity to counterbalance the downward pull of gravity. A spacecraft on a long voyage between planets is actually in orbit around the sun. Here its forward velocity counters the pull of gravity in the manner as a satellite that orbits the Earth. (NASA, 1995)

Two terms often confuse students and even a number of adults. They are rotation and revolution. Rotation means to spin on an imaginary axis. A period of rotation is the time it takes for an object to turn once on its axis. This is also known as one day. Revolution has to do with orbiting. A period of revolution is the time it takes for one object to orbit another. The Earth orbiting the sun. We term this a year. (Coble, Rice, Walla, Murray, 1991)

Two interrelated concepts are difficult for many students to grasp. They are distances in space and the time it takes to travel to different places in the Universe.

The Earth is constantly in motion. It orbits the Sun at a speed of 20km/second. It also orbits the Galaxy, completing one orbit every 200 million years. The Earth has gone around the center of the Milky Way 100 times in the last 4.6 billion years. (Brown, 1996)

When students are asked to define what a billion means, they have a hard time. The following is from Project Spica and is worth putting on an overhead or poster.

Number		*Equals*	*Equals*
1		1 drop	1 drop
10		10 drops	10 drops
100		5ml	teaspoon
1000		50m1	graduated cylinder
10,000		500ml	water bottle
100,000		5 liters	2 1/2 liter bottle
1,000,000	50 liters	3-5 gallon can	
10,000,000	500 liters	approx. 2 barrels	
100,000,000	5000 liters	approx. 20 barrels	
1,000,000,000	50,000liters	1 1/2 (semi) gas truck	

(Braile, 1990)

How long is a billion seconds?

1		1 second
10		10 seconds
100		1-2/3 minutes
1000		approx. 16.7 minutes
10,000		approx. 2.8 hours
100,000		approx. 28 hours
1,000,000	approx. 11.6 days	
10,000,000	approx. 116 days	
100,000,000	approx. 3 years	
1,000,000,000	approx. 31 years	

(Braile, 1990)

Nothing in the Universe travels faster than light. All forms of light travel at the same speed. The speed of light is 299,800,000 meters per second, and is usually rounded off to 300,000,000 meters per second. The speed of sound is only 340 meters per second. (Smith, 1992)

When talking about distance, one term that comes up is an astronomical unit. One astronomical unit is the distance between the center mass of the sun and the center of mass of the Earth-Moon system. (Smith, 1992)

Due to the fact that distances in the Universe are so great, they are on many occasions, expressed in terms of "light years." One light year is equal to the distance light travels in one year. Do this calculation with students:

60 seconds/minute x 60 minutes/hour x 24 hours/day x 365 days/year = 31,536,000

seconds/year. 31,536,000 sec./year x 300,000km/sec. = *9,461 trillion kilometers* = the distance light travels in one year.

This is also equal to approx. 6 trillion miles per year. (Smith, 1992)

It takes sunlight 8.5 minutes to travel to Earth. In other words, the sunlight that is shining on Earth right now is 8 1/2 minutes old. Our closest star—Proxima Centauri is 4.2 light years away. The brightest star, excluding the Sun is 9 light years away. Looking at these stars is like looking back in time. For instance, if an explosion occurred on Proxima Centauri today, we wouldn't know about it for over 4 years. (Smith, 1992)

The diameter of the Milky Way Galaxy is 100,000 light years. Earth is 30,000 light years from the center. We're about 2.2 million light years from the nearest galaxy. (Brown, 1996)

Some additional comparisons of distance and time are as follows: the Moon is 250,000 miles from Earth and it takes light 1.2 seconds to travel there. Mars is 40,000,000 miles away and it takes light 4 minutes to reach there from Earth. Pluto is 3.6 billion miles away and it would take light 5.4 hours to travel from the Earth and reach the farthest planet. (U.S. Space Foundation, 1996)

In the lesson plan section of this unit, I have included a couple of activities relating relative size and distance.

SPACE POLLUTION

Spacecrafts have to be very strong to withstand the elements of space. One problem of space travel that does not receive as much attention as it does on Earth is pollution. Of the approximately 8500 satellites orbiting the Earth, only 5% work. Most of these belong to the United States and Russia. Other countries have filed complaints against the U.S. and Russia through the United Nations,due to their own need of geosynchronous satellite orbits. (Brown, 1996)

In space, satellites and spacecrafts take a beating. They must contend with radiation, erosive matter, the pelting of meteroids, thermal cycling (hot and cold every 90 minutes), ultraviolet radiation, a vacuum, atomic oxygen and tiny fragments of space hardware. (Canby, 1991)

We humans have not only managed to pollute the Earth, but outer space as well. Parts of failing satellites have released all kinds of debris. For example, a hazard of low-Earth orbit could be just a tiny paint chip. Man-made debris numbers in the billions. A speck of paint the size of a grain of salt, caused a pit—200th's of an inch deep one of the Shuttle Challenger's windows and it had to be replaced. Through 1990, 17 shuttle windows, at a cost of $50,000 each have had to be replaced due to damage from man-made objects in outer space. (Canby, 1991)

ASTRONAUTS

Astronauts are selected every 2 years. In order to become an astronaut, one needs a bachelors degree in engineering, biological science, physical science or math. Also needed is three years of professional experience, which can be substituted with a masters or doctoral degree. (NASA, 1990)

55,000 people a year apply to NASA to be astronauts. Of these, 1500 are asked to supply their college grades and a letter as to why they would like to be an astronaut. (Brown, 1996)

Of these, 50 people are invited to the Johnson Space Center to be interviewed and get a physical. Of these, 15 will be invited to become astronauts. (Brown, 1996)

During the physical, you're tested for drugs and your lung capacity is checked. If you have ever used drugs, you're automatically rejected (you went outside the law). Smokers don't pass the lung capacity test. (Brown, 1996)

With a vision or hearing impairment, you're still eligible. If your blood pressures slightly high, that also does hurt your chances of becoming an astronaut. (Brown, 1996)

NASA's shuttle positions are as follows:

> *Commander/Pilot Astronauts*— On board responsibility for their crew's safety and operation. Pilot assists Commander if needed. Pilot helps in satellite retrieval.
> *Mission Specialist Astronauts*— Coordinate shuttle operations, crew activity planning, consumables usage, and experiment and payload operation.They are trained in onboard systems operation and extravehicular activities (spacewalking)
> *Payload Specialists*— These are people that are not part of NASA and they have special on board duties. (NASA, 1993)

To find out about astronaut recruitment write to:. Astronaut Office, Mail Code CB, Johnson Space Center, Houston, Texas 77058.

LIVING AND WORKING IN OUTER SPACE

Science fiction shows present living in outer space and spaceships in somewhat of a luxurious environment. In reality living away from the full effects of Earth's gravity and environment is much different.

Forty percent of all astronauts get space-adaption sickness (nausea, often debilitating). They can't see well for the first few days because of eyeball changes. Chest, neck and their face get wider due to movement of fluid from the lower extremities upward. Excretion of excess fluid—up to 8-10 pounds on a ten day mission. Your back stretches, resulting in back pain for many astronauts. (U.S. Space Foundation, 1996)

Additional microgravity (weightlessness) effects include: Muscle tissue atrophies.
Cardio-vascular system loses efficiency.
Bones lose minerals.
In 28 days, there is a 17% calcium loss. Three to five percent of calcium is lost every month thereafter.
Endocrine system functions less efficiently—including salivary glands.
(U.S. Space Foundation, 1996)

To counteract some of the above effects, astronauts are required to exercise 4 hours per day on a ten day mission and 4-6 hours per day on a longer mission. Also, before landing back on Earth, astronauts must drink two quarts of water with salt tablets during their last orbit—and NASA checks. (Brown, 1996)

One question that most students want answered is, "how do astronauts go to the bathroom?" It takes approximately 45 minutes to go to the bathroom, do to set-up and clean-up. You have to be seat-belted in, with feet restraints. The toilet operates with air, instead of water, the waster then hits a fan and is dried out, collected and frozen in liquid nitrogen. Also, smear samples are taken, frozen in liquid nitrogen, and are checked out on the return home. If an astronaut is participating in a spacewalk, they either wear adult diapers or have a waste elimination tube that goes down to the knee. Astronauts use wipes instead of toilet paper. All types of waste produced by the astronauts is frozen in liquid nitrogen and brought back to Earth. (Brown, 1996)

Astronauts must be team players. They do not take showers. Personal hygiene can be a major source of contention between astronauts. There have been two big fights between astronauts—one on a Russian and one on a U.S. mission. All astronauts involved were asked to resign. (Brown, 1996)

Food for the astronauts is bought at a supermarket, then cooked and frozen. No carbonated beverages are allowed in space because no gas gets absorbed by the digestive system, instead it passes through. (Brown, 1996)

Astronauts are no longer quarantined after the mission, but their immune systems are not 100% for about 28 days. (Brown, 1996)

If you are orbiting the Earth, there are 16-18 sunrises and sunsets daily. Male and female cycles are "off." A day in space usually consists of 22 hours—11 of work, 2 hours for personal hygiene and 4 hours for exercise. (Brown, 1996)

Lastly, if there is a problem in space, NASA has a personal rescue device. This is shaped like a 34 inch diameter ball, with 3-4 hours of life support and communications gear. (NASA, 1993)

If the above is not possible, then there is an agreement between Russia and the United States, not to attempt any further rescue. This is due to the following reasons: decomposition will happen in a spacecraft and when a body decomposes it gives off a lot of toxic gases. Also, for memorial reasons there is no retrieval. (Brown, 1996)

INTERNATIONAL SPACE STATION

Since the fall of the Berlin Wall and the end of the Cold War, countries have been working together, especially for the advancement in science. The future International Space Station is an example of this. As of 1991, there has been 1200 agreements, with more than 135 countries and international organizations pertaining to the station. The Space Station is a result of a partnership between the United States, Japan, Canada, Russia and the European Space Agency. (Canby, 1991)

The Space Station constitutes only one seventh of one percent of the federal budget. Less then fifteen percent of the total NASA budget. It will cost each American about nine dollars per year. It is expected to cost $100 billion over its lifetime (30 years). (NASA 1995)

NASA states that its main goal in building the Space Station is to see how people can live and work safely in space. In addition to the main goal of space adaptation, the microgravity environment will offer a set-up for many experiments unable to be conducted in full Earth gravity. There are thirteen nations involved in these experiments—the largest scientific effort ever. (NASA, 1995)

Further information on the Space Station can be found in the appendix and the International Space Station Fact Book available free from NASA.

THE POSSIBILITY OF LIFE ELSEWHERE IN THE UNIVERSE

This is the stuff of many a students and even an adult's imagination. As mentioned at the beginning of this paper, there are many science fiction shows on television. Also, there have been books, movies, video games and the now infamous radio show, "War of the Worlds." Science fiction both fascinates and terrifies people at the same time.

Students love to talk about this topic as much as possible and it helps to further their interest and enthusiasm for science. Thus I always have a couple of activities pertaining to alien possibilities, as well as a discussion. Due to student interest in this topic, as well as the other ones I have covered, I teach Astronomy at the end of the school year, when minds may not be so focused on schoolwork. This keeps students more focused.

The Drake Equation estimates that there is 10,000 light years distance between intelligent life. In other words, there should be 100,000 intelligent life forms in the Milky Way Galaxy. NASA hopes and believes that evidence of alien life will be found within ten years. (Brown, 1996)

Planets have now been discovered orbiting three stars similar to our own Sun. (Angel, Woolf, 1996)

In the late 1920's and early 1930's, scientist began to direct radio signals at Mars and listen for return signals. We have also been unintentionally sending out signals for years—Star Trek, I Love Lucy, MASH, etc. The SETI program was begun in 1978. It's purpose was to listen for alien signals. It was dropped in 1988 and picked up by private companies. It is now called MEGA. Since we've been listening, there have been eleven signals that can't be decoded. If these or other strange signals get decoded, MEGA has two and a half weeks to notify the general public. Some Third World countries have requested that their public not be notified. (Brown, 1996)

There are seven different centers listening for signals. The largest, with seventeen miles of antenna is in New Mexico. (Brown, 1996)

CONCLUSION

While most people will never become astronauts, there are a lot of related opportunities. According to Vice President Al Gore, the U.S. Aerospace industry employs more than one million people and affects the jobs of fifteen million more. This industry also affects, in one way or another, eighty percent of the U.S. economy. (NASA, 1993)

A great definition of Astronomy and one that fits in well with curriculum requirements is as follows: Astronomy is the process of finding out where we are, our place in space and our position in the unfolding history of the Universe. (Hartmann,Impey,1994)

One final note for anyone doing a unit or research in Astronomy. NASA is a great source for reference material, curriculum ideas and activities, posters, lithographs,videos, slides etc. NASA have proved to be a valuable source for me and I highly recommend contacting them. The teacher resource section has information on how to contact them.

LESSON PLANS: UNIT OBJECTIVES

The following objectives were taken from *Benchmarks for Science Literacy* (1993)

As a result of this unit, students will understand the following:

Some scientific knowledge is very old, yet is still applicable today.

Important contributions to the advancement of science, mathematics and technology have been made by different kinds of people, in different cultures, at different times.

We live on a relatively small planet, the third from the Sun.

Everything on or anywhere near the Earth is pulled toward the Earth's center by gravitational force.

Life is adapted to conditions on the Earth, including the force of gravity.

Nine planets of very different size, composition and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity.

The Earth is orbited by one moon, many artificial satellites and debris.

The Sun's gravitational pull holds the Earth and other planets in their orbits, just as the planet's gravitational pull keeps their moons in orbit around them.

Nothing in the Universe can travel faster then the speed of light, which is the same for all observers, no matter how they or the light source happens to be moving.

Additional objectives:

Students will understand about the vastness of space and the time it would take to travel to various objects in the Universe.

Students will be able to understand and demonstrate Newton' Laws.

As a result of this unit, students will be able to separate fact from fiction when it comes to living and working in outer space.

Students will gain more experience with open-ended problems, performance-based labs, writing across the curriculum and cooperative learning.

LESSON PLANS

As previously mentioned, I teach Astronomy last because it is the favorite unit of many students. With all the curriculum requirements, and pre-requisites for high school, a unit such as this is a great tool.

Days 1-2

Check student's prior knowledge. Give them a question sheet and include such topics as light year, inertia, gravity, etc. Give points for each correct answer and add those to the next test or quiz.

Go over "space basics," such as Newton's Laws, gravity, rotation and revolution. Demonstrate or run labs on these. There are numerous demonstrations, for all levels and learning styles in Prentice Hall texts and activity books. There are also many demonstrations/labs found in NASA publications. These include Rockets and Microgravity. Also, the demonstration on Newton's Third Law, previously mentioned works well. I have included a couple of activities in the appendix.

For homework, due in 2 1/2 weeks, assign a poster project. NASA had designed a plaque that was put on some of our deep space probes, in case of an alien encounter. The purpose was to show what we and the Earth are like. A picture of it, with an explanation is included in the appendix. I have students design their own and it is worth as much as two quizzes. This project is also interdisciplinary, as it has an art and english component. This project also helps students review for the final exam. The instructions for the poster/plaque project are as follows:

You have been selected by NASA to design a plaque/poster that will be placed on the next deep space probe.

The purpose of this plaque is to let aliens know about the Earth.

NASA has requested that your design emphasize Earth Science.

Design your plaque/poster form information found in your book or notes only.

No copying or computer printouts.

Graphs or charts in your own handwriting are okay.

You may use any art form, but the poster must be scientifically correct.

If must cover all the subjects we have studied.

You must include a two page essay along with it—explaining why you included the items on your poster. These will be included on a computer chip to further help the aliens understand the Earth.

I will use a 3 point rubric (similar to the rubric on the Science CAPT) and this project will be equal to two quiz grades.

Students had a lot of fun designing their plaque and I had them present their work to their classmates.

Day #3-Day 5

Go over relative sizes and distances. Also, obtain several Solar System Lithographs Sets from NASA. I laminate these so they last longer.

Next, go over what a billion means (see section of unit on space physics). Demonstrate how much area different amounts of water drops cover (see section of unit on space physics). Then cover and define: light year and astronomical unit. Give example of distances planets, galaxies and stars in terms of light years.

An activity that can be done outdoors comparing relative sizes and distances of the Sun, planets and our Moon, is the following: First go over the solar system, using the lithographs from NASA. On the front are color pictures and on the back are planetary facts. In the appendix, I have included a page on planetary facts and relative sizes of the planets. Then use an activity called, “A Stroll Through the Solar System ,” by Kenneth M. Uslabar from *Science Scope* .

Assign a student to be the Sun, use a bowling ball to represent the star. Have another student represent Mercury and use a pin head to represent this planet. Then assign other students the following. Venus as a peppercorn, Earth also as a peppercorn, the Moon and Mars as pin heads, Jupiter as a chestnut or pecan, Saturn as a filbert or acorn, Uranus as a peanut or coffee bean, Neptune as a peanut or coffee bean and Pluto as a pin head. These are scale models of parts of our Solar System.

The distance scale that Uslabar uses is 1:6,000,000,000. Place the student/planets at the appropriate locations. Review about relative size and distance. Then take a walk, spacing out the Sun and planets. Talk about each object as the walk progresses (or assign students to do that). Spacing is as follows: the Sun is at 0 meters, Mercury is 10 meters from the Sun, Venus is 18 meters from the Sun, the Earth is 25 meters from the Sun, Mars is 38 meters, Jupiter is 130 meters, Saturn is 238 meters, Uranus is 478 meters, Neptune is 749 meters, and Pluto is 983 meters from the Sun.

Day 6

Go over the history of space travel, astronaut selection, and living and working in outer space. For homework, assign a review activity of the lessons so far.

Day 7

Show the Hubble Repair video, produced by NOVA. This video not only shows the steps leading up to and the repair of the telescope, but also shows what it is like to work in space. Along with this, there are some great views of the Earth from outer space and my students are always amazed by these.

Day 8

Review what the students have learned so far. Discuss the Hubble video. Go over the possible Martian mission. Information on this can be obtained from NASA or the U.S. Space Foundation. Have students work in cooperative groups. Their goal is to choose an eight person crew for this mission. The group that comes the closest to what NASA thinks wins a prize. The answers are: A male in the leadership (commander) role, a female psychologist, a teacher who is also a comic, entertainer and a musician, a journalist, a medical doctor/dentist/nutritionist, a cook/masseur/beautician, a communications officer and finally a physical therapist. Note the multiple roles of the crew.

Assign for homework the stranded on the Moon senario. This is a NASA activity from the 1960's, but it is great. A copy of it is in the appendix. Students rank the 15 items in order of importance for survival. I also have them explain their answers.

Day 9

Go over Moon survival answers.

NASA has an excellent teacher's guide with activities called,"Exploring the Moon." Put student's into groups and assign each a task from this. Examples: design a lunar rover, design a development on the Moon. Have one group work on life support systems for a settlement and another one could work on lunar recreation. There are many other activities in this guide to choose from.

Day 10-Day 11

Go over the International Space Station (see appendix for design parameters) and why it is being built.

Have students do performance—based labs. Design the following simulations based on student levels. Cover the following to simulate the needs of the astronauts living there. This is a great time to review the scientific method. Depending on time constraints have each group all of the following or just one, then report their findings back to the class. Topics that should be covered: particulate removal, creating oxygen, getting rid of carbon dioxide, and temperature control/insulation.

Have students write an essay, topic = should the space station be built? Why or why not?

Day 12

Go over the essay from last night.

Go over the possibility of alien life. Separate fact from fiction. Discuss the Drake Equation.

Play “War of the Worlds” for students. Your local library should have a recording of this radio show. I grew up near where they were supposed to have landed and was told that some people fled New Jersey, not knowing that it was a hoax for three weeks.

Plaque is due tomorrow.

Day 13

Have students present their plaques

Day 14

Discuss how we are listening for aliens. What we have found. What do they hear from us.

For homework assign an essay titled,” Should we attempt to contact aliens if we find them? Why or why not?

Day 15-Day 16-Day 17

Invent an Alien Activity/tourism. This is an activity that I have been doing for several years and students have a lot of fun with this. I base it on a Project Spica activity developed by Lois Kittelson (1991)

Students are divided into groups and then assigned a planet. Each group is given the lithograph of their planet and planetary facts. They then must do the following. Draw their aliens. Invent a day in the life of their aliens, base this on Earth’s life characteristics. Also, come up with a tourism campaign for their planet—based on scientific facts. Advertising posters are also required. Students usually have roller coasters, ski resorts or health spas on their planets. They then must give a presentation to their classmates. I’ve even had some students dress up for this. Their creative capabilities shine with this activity and again this is a great activity for the end of the year.

Day 18

Summary of the unit. Include the benefits of space travel and how it has affected of technology.

Additional activities:

- A nighttime star party
- Rocketry demonstrations
- Science Club

TEACHER RESOURCES

Estes Educator Model Rocketry Manual
1295 H Street
Penrose, Colorado 81240
(1) 800 820-0202
Fax(1) 800 820-0203
The Planetary Society
65N. Catalina Avenue
Pasadena, CA 91106
(1) 800-9WORLDS
Sky Interpretation Resource Bulletin or Sky Calendar($7.50/yr.) published by the American Astronomical Society
Abrams Planetarium
Michigan State University
E. Lansing, MI 48824
U.S. Space Foundation
Education Resource Center
2860 South Circle Drive, Suite 2301
Colorado Springs, CO 80906-4184
Astronomy Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 3548592

(to request materials—use stationary with school letterhead)

NASA Goddard Space Flight Center

Teacher Resource Laboratory

Mail Code 130.3

(310) 286-8570

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This is useful for both students and teachers.

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APPENDIX

(figure available in print form)

The above is the engraved plate carried aboard Pioneer 10. It contains information on the position, epoch, and nature of the spacecraft.

(figure available in print form)

INTERNATIONAL SPACE STATION ASSEMBLY COMPLETE

(figure available in print form)

International Space Station Facts and Figures (at Assembly Complete)

(figure available in print form)

International Space Station Facts and Figures (at Assembly Complete)

(figure available in print form)

A Portrait of the Planets

(figure available in print form)

Rocket Car

(figure available in print form)

Rocket Car

(figure available in print form)
Balloon ENGINE
(figure available in print form)
HERO ENGINE
(figure available in print form)