Agronauts After School
an activity guide for space biology

www.ncsu.edu/project/agronauts
Activities

The Celestial Dome Planisphere  Mission 1
Moon Phases  Mission 1
If the Moon were a penny  Mission 1
Distance to the Moon  Mission 1
Germination  Mission 2
Build a Light Box  Mission 2
Making Craters  Mission 3
Do plants really need soil?  Mission 3
Which lights do plants like?  Mission 4
What color is light?  Mission 4
What color is light (II)?  Mission 4
Plants in Space  Mission 5
Puffy Face Syndrome  Mission 5
Boney Bones  NASA
Just a Little Air in My Gel  NASA

A detailed description of each activity can be found on the Adventures of the Agronauts Website
www.ncsu.edu/project/agronauts
Activity Descriptions

Celestial Dome Planisphere

A planisphere, or a star chart, allows you to see which constellations are up on a given day or time. This activity, developed by Ken Wilson at the Science Museum of Virginia, is an excellent way to give each student a planisphere for home use. The other perk to this activity is that the only cost is for the CDs (~$30 for 30 disks). Most commercially available planispheres cost $6-10 each, so this is a great alternative!

If the Moon were a Penny…

It is interesting to realize that we only ever see one side of the Moon from Earth. This exercise serves to help students visualize why that phenomenon occurs. This activity will be most impactful if each student has the opportunity to perform it.

Distance to the Moon

Often times, students have difficulty visualizing exactly how large the Earth and Moon are by just reading metric distances. In this activity, students compare the Earth and the Moon to sports balls in order to gain a better understanding of the distance from the Earth to the Moon.

Germination

Use this activity to help students examine the environmental conditions needed for germination. The activity uses 35mm film canisters that can generally be obtained free from your local film development locations. Obtain as many as you can! The great thing about using canisters is that they are small and students can test their own hypotheses about germination rather easily using the canisters. Do be aware that some experiments require that seeds be watered and placed in canisters with no holes. If these canisters containing wet seeds/seedlings are left unattended for over a week, expect a pungent odor when you open them!

Build a Light Box

A light box is a wonderful way to enhance your classroom environment to keep your students' interest in plants. You could build one light box for your room, or have teams of students build light boxes for their experiments. We suggest that you build the light boxes (see link below for a photo) before you begin work on Mission 2, as you may want to go ahead and have some plants growing inside to peak student interest in the lessons ahead.
This experiment gives instruction on how to make a light box, but if you desire a larger display, there are also instructions (and photos) on how to make a light bank system at http://www.fastplants.org/instructions/lighting_systems.html - A light bank system could also be set up in the school lobby to attract school-wide interest. This project is a good candidate for parent, PTSA and community involvement. If you have a budget allowance, plant light houses are also commercially available from Carolina Biological, Inc. for $74.95 (Catalog # WW-15-8994).

Making Craters

Use this activity to help students practice measuring diameters by creating impact craters and relating this data to the Moon surface. You may want to consider conducting this experiment outside or on a surface that is easily swept in case there are any spills. Students will use pebbles 1-4 cm in diameter for this activity. You could have the students practice using rulers to gather the pebbles for the activity from the school grounds.

Do Plants really need Soil? (I)

This activity introduces students to hydroponics, a special way to grow plants without soil. Hydroponic systems have been tested in space because they offer a soil-free way of delivering nutrients to plants in space. In some designs, the plant roots wrap around porous ceramic tubes that continuously deliver water and nutrients to the plants. Hydroponic garden activities have a great deal of potential. Students can grow the same plants in soil and in the hydroponic system and compare certain characteristics or features of the plants that result. They could even grow vegetables and have a tasting party to determine if they detect a difference in taste! Students can be assigned sides of a debate - growing plants in soil vs. growing plants with hydroponics - what are the pros and cons? They will find that there are some strong opinions out there! And of course, anything grown in your classroom hydroponically could be used as part of a service or beautification project that allows students to share their plants with others and teach them about what they have learned.

When examining the procedure for growing plants hydroponically, you may notice that floral foam is required. Why? The seeds need some type of inert structure for support and for water transport but as the source of nutrients, like soil. The nutrients will come from the fertilizer that is dissolved in the water. You may want to test the floral foam that you obtain to see how well it absorbs water.

An easy hydroponic system for beginners can be found at the Donna's Day website, http://www.donnasday.com/donna/creativefun/activities/hydroponics.shtml. You will need a container that holds at least 6" of water, a Styrofoam sheet, floral foam, hydroponic nutrient solution, and seeds.
Which Lights do Plants Like?

This activity relates light, color, plants and space travel. The activity uses 35mm film canisters that can generally be obtained free from your local film development locations. Obtain as many as you can! Seedlings will be exposed to red, green and blue light. The seedlings will grow towards the blue and red lights. Why? Plants are green because they reflect green wavelengths of light. This means that plants do not absorb and use green wavelengths of light. So, plants will grow towards red or blue light that they can use to make food. What does this mean for space travel? One goal in space travel is to use minimal amounts of energy to accomplish tasks. So, instead of shining white light (all wavelengths of visible light) onto plants, scientists are studying the growth of plants under red and blue lights to reduce the amount of light energy that might be required for long duration space travel.

What Color is Light (I)

This activity will show students that white light is actually made up of many colors. You may want to use this demonstration before you introduce students to concepts of light and the visible spectrum. We suggest that you try this experiment before showing it to the students. Determine the best position for the glass and the best time of the day to use this demonstration depending on your light availability. Make sure you can find the location of the spectrum pattern on the floor. Also, you may want to leave the glass of water in this position all day and have the students observe how the pattern changes throughout the day.

What Color is Light (II)

This experiment re-emphasizes the relationship between white light and the colors of the visible spectrum. This may be an excellent activity to use in coordination with your art teacher. As students spin their color disc, the disc will appear pale gray instead of white. Explain to the students that they probably will not be able to achieve a white disc because the colors in the crayons, paint or markers are not pure enough.

Plants in Space

This activity demonstrates a unique challenge of studying and growing plants in space: different parts of the plant respond to gravity in different ways, and scientists are not yet sure why. Roots grow down, and shoots grow up. The activity uses 35mm film canisters that can generally be obtained free from your local film development locations. Obtain as many as you can! In this canister experiment, students attach a seedling to a canister lid so that the shoot sticks straight out into the canister. They are asked to predict how the shoot will grow and check it in three days. Some students predict that the shoot will grow roots and move downward…you will get all kinds of predictions! However, the shoot...
will turn to grow upward. This may surprise many students, but this shows how shoots respond to gravity. Shoots are negatively gravitropic, meaning they grow away from the direction of the force of gravity. In space, the limited effect of gravity makes plant roots and shoots grow in random directions. Though gravity is not one of the 7 things that plants need to live, students may want to consider this factor as they think about the design of their chamber on the Moon, which has 1/6 Earth's gravity.

A Spacelab Experiment: Which Way is Up?

On Earth, the roots of plants grow down and the stems grow up. This five-day experiment investigates which way plants grow in space. One plant represents plants on Earth and another plant represents plants in space.

Puffy Face Syndrome

This activity simulates one effect of spaceflight on the human body, the cephalad fluid shift. On Earth, our heart pumps blood upward towards the head, but gravity pulls it back down through our body and extremities. In microgravity, the heart still pumps the blood towards the head, but there is too little gravity to pull it downward. This causes astronaut faces to look puffy or swollen for a couple of days. At the same time, their leg circumference shrinks. This all evens out eventually. When we wake up in the morning, our heads are slightly larger than they will be at any other time of the day. Why? Because we have been lying down and gravity does not work on our body the same way when we lie down as it does when we stand upright. The puffy face syndrome astronauts experience can be simulated by having one student in a team of two lie down for several minutes (at least 10, and it helps if their feet are up in a chair). When the student measures the head of the "astronaut" after lying down for several minutes, it should be larger in circumference. Be aware that data will vary. You may have heads that do not change or that even get smaller! This is a great opportunity to talk about scientific experiments. Ask students to come up with reasons why their hypothesis may not have been proven with this experiment. Ask them to consider the processes of doing good science.

Boney Bones

When astronauts go into space, the stress upon bones is reduced causing the astronauts’ bones to weaken. When this happens, calcium is released into the bloodstream and the kidneys must filter the calcium rich blood. In this activity, students create a small simulation of this process. A cup of cereal, representing bone material, is placed in a zip lock bag. Students slowly apply pressure to the cereal, causing a light residue to form on the inside of the bag. In the second part of the experiment, students place warm water in a bowl. Next, antacid tablets are placed in the water. The water is then slowly poured in
to the coffee filter. After the filter is dry, students use a magnifying glass to observe the surface of the filter.

**Just a Little Air in My Gel**

In this experiment, students learn about aerogel, a strong yet lightweight man-made material. Aerogel has many uses, but it is currently being used to capture comet particles. Students will create a small representation of aerogel, blow “comets” (candy) into the gel, and observe the tracks the comet leaves.
Phase 1 - New Moon

Phase 2 - Waxing Crescent Moon

Phase 3 - First Quarter Moon

Phase 4 - Waxing Gibbous Moon

Phase 5 - Full Moon

Phase 6 - Waning Gibbous Moon

Phase 7 - Last Quarter Moon

Phase 8 - Waning Crescent Moon
Objectives:
- To understand the ways in which objects move around themselves and one another.
- To explore the unique phenomena about how we see the Moon from Earth.

Initial Questions:
1. What does it mean if an object rotates?
2. What does it mean if an object revolves?

In this activity, we are going to model the rotation and revolution of the Moon around the Earth by using two coins.

Materials
One penny, one other larger coin, marker, table

Procedure:
In order to mimic the way the Moon moves around the Earth:
1. Obtain two coins – a penny to represent the Moon and another coin larger in size to represent the Earth.
2. Place the two coins on a table or desk.
3. Choose a particular place on the edge of the "Moon" as a reference point and mark it with a small mark.
4. Now, move the Moon around the Earth to make one complete circle, but be careful to always keep the spot you picked pointed at the Earth.

You have just made a model of the way the Moon moves in relation to the Earth.

Questions:
1. In your model, how many times did the “Moon” revolve?
2. How long does it take for the Moon to revolve around the Earth?
3. In your model, how many times did the “Moon” rotate?
4. How long does it take for the Moon to rotate?
5. What do you notice about the time it takes for the Moon to revolve and the time it takes for the Moon to rotate?
6. What does this mean about how we see the Moon from Earth? Repeat the activity, paying special attention to your mark on the penny. Pretend you are on the coin representing the Earth. What would you see as the Moon rotates and revolves?
Distance to the Moon

Purpose
To calculate the distance between scale models of Earth and the Moon.

Key Word
scale

Materials
"Moon ABCs Fact Sheet"
sports balls
calculator
meter tape

Procedure
1. If Earth were the size of an official basketball, then the Moon would be the size of: another basketball? soccer ball? baseball? tennis ball? golf ball? marble?

2. The diameter of Earth in kilometers is:

3. The diameter of the Moon in kilometers is:

4. What percentage of Earth's diameter is the Moon's diameter?

5. Use the list below to change or confirm your answer to Question 1.

<table>
<thead>
<tr>
<th>Sport</th>
<th>Diameter in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>official basketball</td>
<td>24</td>
</tr>
<tr>
<td>size 5 soccer ball</td>
<td>2.2</td>
</tr>
<tr>
<td>official baseball</td>
<td>7.3</td>
</tr>
<tr>
<td>tennis ball</td>
<td>6.9</td>
</tr>
<tr>
<td>golf ball</td>
<td>4.3</td>
</tr>
<tr>
<td>marble</td>
<td>0.6</td>
</tr>
</tbody>
</table>

If Earth is a basketball, then the Moon is a:
6. Use an official basketball as a model of Earth. Use a second ball, the one you determined from Question 5, as a model of the Moon.

7. Determine the scale of your model system by setting the diameter of the basketball equal to the diameter of Earth.

\[
\text{________ cm} = \underline{\text{________________}} \text{ km} \quad \text{therefore,}
\]

\[
1 \text{ cm} = \underline{\text{____________}} \text{ km}
\]

8. If the distance to the Moon from Earth is 382,500 km, then how far apart must you separate the two scale models to accurately depict the Earth/Moon system?

Using the scale value in the box from Step 7, the model separation in centimeters (x) is derived:

\[
x = \frac{\text{actual distance to the Moon in kilometers}}{\text{scale value in kilometers}}
\]

\[
x = \underline{\text{____________}} \text{ centimeters}
\]

The two scale models must be separated by ________ meters.

9. Set up your scale model of the Earth/Moon system. Does it fit in your classroom?
<table>
<thead>
<tr>
<th>Property</th>
<th>Earth</th>
<th>Moon</th>
<th>Brain Busters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equatorial diameter</td>
<td>12,756 km</td>
<td>3,476 km</td>
<td>How long would it take to drive around the Moon's equator at 80 km per hour?</td>
</tr>
<tr>
<td>Surface area</td>
<td>510 million square km</td>
<td>37.8 million square km</td>
<td>The Moon's surface area is similar to that of one of Earth's continents. Which one?</td>
</tr>
<tr>
<td>Mass</td>
<td>$5.98 \times 10^{24}$ kg</td>
<td>$7.35 \times 10^{22}$ kg</td>
<td>What percentage of Earth's mass is the Moon's mass?</td>
</tr>
<tr>
<td>Volume</td>
<td>---</td>
<td>---</td>
<td>Can you calculate the volumes of Earth and the Moon?</td>
</tr>
<tr>
<td>Density</td>
<td>5.52 grams per cubic cm</td>
<td>3.34 grams per cubic cm</td>
<td>Check this by calculating the density from the mass and volume.</td>
</tr>
<tr>
<td>Surface gravity</td>
<td>9.8 m/sec/sec</td>
<td>1.63 m/sec/sec</td>
<td>What fraction of Earth's gravity is the Moon's gravity?</td>
</tr>
<tr>
<td>Crust</td>
<td>Silicate rocks. Continents dominated by granites. Ocean crust dominated by basalt.</td>
<td>Silicate rocks. Highlands dominated by feldspar-rich rocks and maria by basalt.</td>
<td>What portion of each body is crust?</td>
</tr>
<tr>
<td>Mantle</td>
<td>Silicate rocks dominated by minerals containing iron and magnesium.</td>
<td>Similar to Earth.</td>
<td>Collect some silicate rocks and determine the density. Is the density greater or lesser than the Earth/Moon's density? Why?</td>
</tr>
<tr>
<td>Property</td>
<td>Earth</td>
<td>Moon</td>
<td>Brain Busters</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Core</td>
<td>Iron, nickel metal</td>
<td>Same, but core is much smaller</td>
<td>What portion of each body is core?</td>
</tr>
<tr>
<td>Sediment or Regolith</td>
<td>Silicon and oxygen bound in minerals that contain water, plus organic materials.</td>
<td>Silicon and oxygen bound in minerals, glass produced by meteorite impacts, small amounts of gases (e.g., hydrogen) implanted by the solar wind. No water or organic materials.</td>
<td>Do you think life ever existed on the Moon? Why or why not?</td>
</tr>
<tr>
<td>Atmosphere (main constituents)</td>
<td>78 % nitrogen, 21 % oxygen</td>
<td>Basically none. Some carbon gases (CO₂, CO, and methane), but very little of them. Pressure is about one-trillionth of Earth's atmospheric pressure.</td>
<td>Could you breathe the lunar atmosphere?</td>
</tr>
<tr>
<td>Length of day (sidereal rotation period)</td>
<td>23.93 hours</td>
<td>27.3 Earth days</td>
<td>How long does daylight last on the Moon?</td>
</tr>
<tr>
<td>Surface temperature</td>
<td>Air temperature ranges from -88°C (winter in polar regions) to 58°C (summer in tropical regions).</td>
<td>Surface temperature ranges from -193°C (night in polar regions) to 111°C (day in equatorial regions).</td>
<td>Why are the temperatures of Earth and the Moon so different?</td>
</tr>
<tr>
<td>Surface features</td>
<td>25 % land (seven continents) with varied terrain of mountains, plains, river valleys. Ocean floor characterized by mountains, plains.</td>
<td>84 % heavily-cratered highlands. 16 % basalt-covered maria. Impact craters--some with bright rays, crater chains, and rilles.</td>
<td>Compare maps of Earth and the Moon. Is there any evidence that plate tectonics operated on the Moon?</td>
</tr>
</tbody>
</table>
Objectives
Determine what conditions seeds need in order to germinate
Observe the effects on seeds and seedlings when the best conditions are not present for germination and growth

Initial Questions

Materials
- 35mm film canisters (use the gray canisters, not the translucent ones)
- radish seeds
- tape
- single hole punch
- refrigerator
- window or light source (light box would work)
- 2.5cm square paper towels
- pipette or dropper
- pennies
- water

Procedure
You will be making 5 different chambers and comparing the seed germination in each.

Chamber #1: Control
1. Punch three holes in the film canister, all approximately the same distance from the open end.
2. Tape clear plastic over each hole using clear tape. Cover the holes completely to maintain humidity in the canister.
3. Place the canister lid on the table. On the inside of the lid, place a square of paper toweling and wet the square.
4. Place 3 radish seeds on the wet paper towel square.
5. Leaving the lid on the table, snap the canister down onto the lid. Leave the canister upside down.
6. Place the chamber under bright (but not hot) light. All three holes should receive about the same amount of light.
7. After 3 days, open the chamber and observe the orientation of your plants.

Chamber #2: Light
1. Do no punch holes in the canister. Place the canister lid on the table. On the inside of the lid, place a square of paper toweling and wet the square.
2. Place 3 radish seeds on the wet paper towel square.
3. Leaving the lid on the table, snap the canister down onto the lid. Leave the canister upside down.
4. After 3 days, open the chamber and observe the orientation of your plants.
Germination Activity
Mission 2

Chamber #3: Temperature
1. Punch three holes in the film canister, all approximately the same distance from the open end.
2. Tape clear plastic over each hole using clear tape. Cover the holes completely to maintain humidity in the canister.
3. Place the canister lid on the table. On the inside of the lid, place a square of paper toweling and wet the square.
4. Place 3 radish seeds on the wet paper towel square.
5. Leaving the lid on the table, snap the canister down onto the lid. Leave the canister upside down.
6. Place the chamber in the refrigerator.
7. After 3 days, open the chamber and observe the orientation of your plants.

Chamber #4: Gravity
1. Take a canister and tape a penny to the side of the canister. This will help balance the canister on its side. Do not punch holes in the canister.
2. Place the canister lid on the table. On the inside of the lid, place a square of paper toweling and wet the square.
3. Place 3 radish seeds on the wet paper towel square.
4. Leaving the lid on the table, snap the canister down onto the lid. Turn the canister on its side so that it balances on the penny.
5. After 3 days, open the chamber and observe the orientation of your plants.

Chamber #5: Water
1. Punch three holes in the film canister, all approximately the same distance from the open end.
2. Tape clear plastic over each hole using clear tape. Cover the holes completely to maintain humidity in the canister.
3. Place the canister lid on the table. On the inside of the lid, place a square of paper toweling. Do not wet it.
4. Place 3 radish seeds on the paper towel square.
5. Leaving the lid on the table, snap the canister down onto the lid. Leave the canister upside down.
6. Place the chamber under bright (but not hot) light. All three holes should receive about the same amount of light.
7. After 3 days, open the chamber and observe the orientation of your plants.

Credits: This experiment is an adaptation of activities from Wisconsin Fast Plants, http://www.fastplants.org, and NSCORT at NC State University, http://www.cals.ncsu.edu/nscort/
Questions

<table>
<thead>
<tr>
<th>Canister #</th>
<th>Observations after 3 days</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Why is it important to have a control in an experiment?

Why do you think we punched holes in some canisters and not in others?

What do your results teach us about growing plants in space?

Can you think of other germination experiments you would like to try with your canisters?

In canister #2, pay special attention to the color and shape of the seedlings when you first open the canister. Now, transplant the seedlings from Canister #2 into a canister with holes on a windowsill. What do you notice the next day? What is the relationship between plants, light and food production?
Objectives
Create an environment where plants can receive adequate and controlled lighting
Create a space for future plant experiments in the classroom

Materials
- One empty "copy paper" box, (e.g., Xerox)
- Aluminum foil (approximately 10-15 feet)
- Electrical cord with socket
- Plastic plate or lid (5-10 inches in diameter)
- Glue stick
- Clear tape
- Scissors
- 30-watt fluorescent circle light OR a 39-watt fluorescent circle light

Procedure
1. Cut a 1-inch hole in the center of a plastic plate or lid and trim off edges to make approximately a 4-5 inch disk with a center hole.
2. Cut several 4 X 14-cm ventilation slots in top, upper sides and back of box as shown.
3. Cut a 1-inch diameter hole in the center of box.
4. Apply glue stick to the each inner surface of the box and paste in aluminum foil to cover entire surface. Use tape to reinforce corners and edges.
5. Insert light fixture base through hole in top and through plastic plate from the inside of the box. Secure fixture by attaching socket from the outside of the box.
6. Tape an aluminum foil or reflective full-length mylar curtain to the top front edge of box. Let curtain hang down in front.
7. Strengthen curtain edges with tape.

Credit: This activity is from Wisconsin Fast Plants,
http://www.fastplants.org/instructions/lighting_systems.html
Objectives
Understand how size of a meteor influences crater formation
Understand how speed of a meteor influences crater formation

Initial Questions
Which would make a larger crater (in diameter) if it hit the Moon? – a meteor with 6” or 12” diameter? Why?

Would a 6” meteor make a larger crater (in diameter) if it hit the Moon at 100 km/hr or 200 km/hr? Why?

What factors might affect the height of the crater walls?

Materials
• Shallow basin at least 1 square foot (30 centimeters) - cat liter boxes work well
• bags of unbleached flour
• box of instant cocoa
• several pebbles of various sizes -1/3 to 1 1/2 inches (1 to 4 centimeters)
• old newspaper
• ruler
• pen or pencil
• chair
• data sheet

Procedure
Meteor Size
1. Spread old newspaper out in an area where you will conduct this activity.
2. Fill a basin with flour about 1 1/4 to 1 1/2 inches (3-4 centimeters) deep. Sprinkle a little cocoa on the surface. This will make the changes caused by the pebbles more visible. Gather the various pebbles; they will be the “meteoroids.”
3. Pick out one of the smallest pebbles and measure its diameter in cm. Record this number on the chart below.
4. Have a student volunteer to drop (not throw) the pebble from about eye level into the basin.
5. Measure the diameter and height of the crater and record your data in the chart below. Also describe any other observations. Now, try to predict the appearance of a crater formed by a larger pebble dropped from the same height.
6. Aiming for a different area of the pan, have the same student volunteer drop a medium size pebble from about the same height. What is different about the crater? Record the same information on the chart as you did above.
Making Craters  Activity  
Mission 3

7. Have the same student volunteer drop the largest pebble from the same height. Record your results.

Meteor Speed
8. You will use the same pebble for each step of this activity. Select a medium-size pebble and measure its diameter. 
9. Have a student volunteer to drop (not throw) the pebble from about knee level into the basin. 
10. Measure the diameter and height of the crater and record your data in the chart below. Also describe any other observations. Now, try to predict the appearance of a crater formed by the same pebble but dropped from a higher place. 
11. Have the same student volunteer drop the medium size pebble from eye level. What is different about the crater? Record the same information as before in the chart below. 
12. Have the same student volunteer to stand in a sturdy chair, raise his or her hand straight up, and drop the medium size pebble from that level. What is different about the crater? Record your results.

Questions
Use the charts below to record your data.

<table>
<thead>
<tr>
<th>Size of Meteor</th>
<th>Diameter of pebble (in cm)</th>
<th>Diameter of crater formed (in cm)</th>
<th>Height of crater formed (in cm)</th>
<th>Other Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small pebble</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium pebble</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large pebble</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed of Meteor (medium pebble only)</th>
<th>Diameter of pebble (in cm)</th>
<th>Diameter of crater formed (in cm)</th>
<th>Height of crater formed (in cm)</th>
<th>Other Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing on chair with extended arm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Credit: This activity was adapted from At Home Astronomy, http://cse.ssl.berkeley.edu/AtHomeAstronomy/
Making Craters Activity
Mission 3

Describe in one or two sentences the relationship between meteor size and craters.

Describe in one or two sentences the relationship between meteor speed and craters.

Locate a map of the Moon. Relate your data to the various craters that you see on the Moon, and try to predict what type of meteor may have caused some of the craters.

Credit: This activity was adapted from At Home Astronomy, http://cse.ssl.berkeley.edu/AtHomeAstronomy/
Here are some tips on growing vegetables and flowers using hydroponics:

1. You can use any clean container that will hold at least six inches of water.
2. It is important to use a fertilizer made especially for hydroponics. Add one teaspoon of fertilizer per gallon of water. Hydroponics fertilizers are available at garden stores, some hardware stores, and nurseries, or you can go on line to a Hydroponics Garden website.
3. Start seeds in floral oasis that will soak and absorb water. Peat pots are an alternative that you can use. Follow the directions on the seed package to determine how deep and how far apart you should plant your seeds. Examples: lettuce seeds should be barely covered, and they should be planted at least 4 inches apart. Most flower seeds can be planted closer together.
4. Insert the pods containing the seeds into a sheet of styrofoam that has holes cut out just large enough to hold the pods. Make sure the styrofoam goes from edge to edge of your container so that no light can get in.
5. Light is critical to growing the plants on top. However, the roots need complete darkness. If your container is not dark, algae will bloom and it will consume all the nutrients that should be feeding your plant. Cover the sides of your container with cardboard or aluminum foil or any other material that will block out all light.
6. Constantly check the level of the water, because it will evaporate. Keep it consistent at a minimum of 6 inches.
7. Plants grown with hydroponics can be successfully transplanted outdoors, provided the climate is right. Consult your seed package to know when the right time of year is to transplant.
8. It is always fun to stagger the planting of lettuces and other vegetables, so that you always have a fresh supply. Plant new seeds every 3-4 weeks regularly, and you will enjoy fresh salads all through the winter months!
Which lights do plants like?  

Activity 
Mission 4

Objectives
Relate the color of plants to their use of visible light
Apply observations to conditions of space travel
Observe phototropism

Initial Questions
Have you ever seen plants bend or grow in certain ways as they respond to something?
What are some of the things plants respond to?

In this experiment, you will observe plant response to light. This is an important consideration in long-duration space travel. White light contains all colors of the spectrum, however plants use some wavelengths of light moreso that others. If scientists know which wavelengths plants need to grow and make food, then we can save energy by just exposing plants to those wavelengths instead of to white light. We will be examining red, green and blue light. Which of these wavelengths of light do you think plants use to make food and grow?

Materials
- 35mm film canister (use the opaque gray canisters, not the translucent ones)
- radish seeds
- 2.5cm squares of red, green and blue cellophane paper
- clear tape
- single hole punch
- red, green and blue markers
- 2.5cm square paper towels
- pipette or dropper
- water

Procedure
1. Punch three holes in the film canister, all approximately the same distance from the open end.
2. Tape a different colored square of plastic over each hole using clear tape. One hole will be red, one green and one blue. Cover the holes completely to maintain humidity in the canister.
3. Place the canister lid on the table. On the inside of the lid, place a square of paper toweling and wet the square.
4. Place 3 radish seeds on the wet paper towel square.
5. Leaving the lid on the table, snap the canister down onto the lid. Leave the canister upside down.
6. Use a red marker to mark the side where red paper covers the hole. Repeat this for the blue and green holes. This will help you when you remove the chamber from the lid in a few days and observe the plants' direction of growth.
7. Place the chamber under bright (but not hot) light. All three holes should receive about the same amount of light.
8. After 3 days, open the chamber and observe the orientation of your plants.

Credits: This experiment is an adaptation of activities from Wisconsin Fast Plants, http://www.fastplants.org, and NSCORT at NC State University, http://www.cals.ncsu.edu/nscort/
Which lights do plants like?

Credit: This experiment is an adaptation of activities from Wisconsin Fast Plants, [http://www.fastplants.org](http://www.fastplants.org), and NSCORT at NC State University, [http://www.cals.ncsu.edu/nscort/](http://www.cals.ncsu.edu/nscort/)

**Questions**
Which way did each seedling grow? Did they grow in the same direction? How many seedlings bent? Compare your results with the rest of the class.

What can you conclude about the effects of green, red and blue light on the seedlings? Which color(s) did plants bend towards the most?
What Color is Light?  
Demonstration  
Mission 4

Objectives  
To understand the nature and components of visible light through observation

Initial Questions  
What color is light?

How do you know this?

Materials and Notes

- Clear, straight-sided glass
- Water
- window/sunlight
- white posterboard paper
- crayons or markers.

Procedure

1. Fill the glass with water.
2. Place the glass on the edge of a table close to the window where direct sunlight will reach the glass.
3. Place the paper on the floor in front of the table and in line with the glass. Move the paper back and forth until you see something interesting. Mark your observations on the paper.

Questions

Describe the appearance of the light from the flashlight or window that is on one side of your glass of water.

Describe what you observed on the paper. What do you think happened?

What color is light?

Credit: adapted from Riverdeep – Resources on the Nature of Light,  
http://www.riverdeep.net/current/2002/01/010702_light_to.jhtml
Objectives
To understand the nature and components of visible light through observation

Initial Questions
What is a spectrum?

Do you know any colors in the spectrum that you can mix together to get other colors?

What would happen if you mixed all colors of the spectrum together?

Materials and Notes
• Small round bowl – approximately 6” in diameter
• Sharp pencil
• White construction paper or card stock
• Protractor
• Crayons, paint or markers

Procedure
1. Trace the edge of a round bowl on a piece of white paper.
2. Cut the circle you traced out of the paper.
3. Use a protractor to divide the circle into 7 equal wedges (51.5° each). Color each segment in order according to the colors of the spectrum: red, orange, yellow, green, blue, indigo, violet.
4. Punch a small hole in the center of the circle with your pencil. Place the pencil in the hole.
5. Spin the circle on the sharpened end of the pencil as quickly as possible.

Questions
What did you observe when you spun your color wheel?

Was this different from what you expected to see?

What might be some reasons for the difference in what you expected and what you saw?
Plants in Space

Activity
Mission 5

Objectives
Understand how plants respond to gravity on Earth
Predict plant responses in environments different from Earth

Initial Questions
How do people know which way is up or down? Is there a part of our bodies that helps us to know?

If you take a potted plant and lay it on its side, what will happen to the part of the plant above ground? Why do you think this happens?

What will happen to the roots of the potted plant when turned on its side?

Materials
35mm film canister (use the gray canisters, not the translucent ones), radish seedlings (~ 7-8 days old), tape, 2.5cm square paper towels, water

Procedure
1. Take a canister and tape a penny to the side of the canister. This will help balance the canister on its side.
2. Place the canister lid on the table. Double up a piece of tape so that it is sticky on all sides. Press the tape on the inside of the lid.
3. Pinch off a radish seedling about 1” in length. Make sure you only have shoot material, no roots.
4. Press the two leaves of the seedling onto the tape. The end of the shoot should be sticking straight out.
5. Place a paper towel square in the bottom of the canister and wet it.
6. Snap the lid onto the canister. Turn the canister on its side so that it balances on the penny.
7. After 3 days, open the chamber and observe the orientation of your shoot.

Questions
What did you observe after three days?

Plants respond to gravity, and different parts respond in different ways. How do you think the different parts of plants behave in a microgravity environment?

Credits: This experiment is an adaptation of activities from Wisconsin Fast Plants, http://www.fastplants.org, and NSCORT at NC State University, http://www.cals.ncsu.edu/nscort/
Objectives
Observe an effect of microgravity on the human body

Initial Questions
What are some of the effects of gravity on the human body here on Earth?

How might the human body be different in space, a microgravity environment?

This experiment simulates one effect that astronauts experience in space. On Earth, our heart pumps blood up towards our head, but gravity helps to pull the blood down into our extremities. In space, there is no significant gravity present to pull the blood into the extremities. What effect do you think this will cause at the head of the human body? In the legs of the human body? Let’s see if our predictions can be modeled on Earth.

Materials
Tape measure (or, string and a meter stick), student volunteer(s), chair, chalkboard or whiteboard for recording results

Procedure
1. Have one student volunteer to be an “astronaut” and select another student to perform the experiment on the astronaut.
2. The experimenter should measure the circumference of the astronaut’s head using a tape measure. Record the circumference in cm in the Before column.
3. Have the astronaut to lie down on the floor with his or her feet propped up into a chair. The astronaut should lie in this position for at least 5 minutes.
4. When this time period is over and while the astronaut is still lying down, the experimenter should measure the circumference of the astronaut’s head a second time. Record this result in the After column.
5. Calculate the difference.

<table>
<thead>
<tr>
<th>Astronaut Name</th>
<th>Before (cm)</th>
<th>After (cm)</th>
<th>Difference (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions
What change, if any, did you observe in the circumference of the astronaut’s head?

Based on the information you were given before starting the experiment, what did you hypothesize would happen?

Credit: This activity was developed by the NSCORT at NC State University, http://www.cals.ncsu.edu/nscort/
Was your hypothesis proven by the data? If it did not, record your thoughts on how the experiment could be changed and attempted again.

If your hypothesis was not proven in this experiment, did that mean your hypothesis was wrong? Please explain your answer.