Teacher’s Guide for *Observing Visitors from Outer Space*

List of Materials for a class of 24 students to make and take a cloud chamber device. 8 Groups of 3. Locations are in Ithaca, New York. Prices are approximate.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Where obtained</th>
<th>Quantity and cost for 8 groups of 3 students.</th>
<th>Actual Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Cups</td>
<td>Tops Grocery</td>
<td>Stack of 20 9-oz (1.50)</td>
<td>8 cups</td>
</tr>
<tr>
<td>Isopropyl Alcohol (91%) NOT 70%</td>
<td>Tops Grocery</td>
<td>32 oz or 946 mL Bottle (2.50)</td>
<td>¼ of the bottle</td>
</tr>
<tr>
<td>Small Cotton balls</td>
<td>Tops Grocery</td>
<td>Bag of 300 ($1.50)</td>
<td>40 cotton balls</td>
</tr>
<tr>
<td>Dark plastic garbage bag</td>
<td>Tops Grocery</td>
<td>Box of 10 ($2)</td>
<td>One bag</td>
</tr>
<tr>
<td>Roll of aluminum foil</td>
<td>Tops Grocery</td>
<td>Box ($1)</td>
<td>2 feet</td>
</tr>
<tr>
<td>Paper cereal bowls</td>
<td>Tops Grocery</td>
<td>Stack of 24 ($2.50)</td>
<td>8 bowls</td>
</tr>
<tr>
<td>Paper towels</td>
<td>Supplied by School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha particle emitters</td>
<td>Kmart</td>
<td>Set of 6 ($5 each)</td>
<td>All</td>
</tr>
<tr>
<td>Flashlights</td>
<td>Kmart</td>
<td>Set of 12 ($2 each)</td>
<td>All</td>
</tr>
<tr>
<td>Thick (#64) rubber bands</td>
<td>Office Max</td>
<td>Bag ($3)</td>
<td>16 rubber bands</td>
</tr>
<tr>
<td>Thin rubber bands</td>
<td>Office Max</td>
<td>Bag ($3)</td>
<td>8 rubber bands</td>
</tr>
<tr>
<td>Silicone based household glue</td>
<td>Bishop’s Hardware</td>
<td>Tube ($3.50)</td>
<td>¼ of the tube</td>
</tr>
<tr>
<td>Dry ice</td>
<td>Purity Ice Cream</td>
<td>4 pounds (2 kg) by the time you use it in class. <em>(1.50/lb x 4 lbs = $6)</em></td>
<td>All</td>
</tr>
</tbody>
</table>

* The dry ice begins sublimating as soon as you leave the store. Keep it in a tote cooler. If you are purchasing the dry ice a day in advance, it is possible to keep it until the next day. Place the tote cooler inside another cooler. Expect about 4 pounds to sublime overnight. For a single class, you will thus need 4 lbs + 4 lbs = 8 lbs, costing about $1.50 x 8 = $12. For two classes you would need 2 x 4 lbs + 4 lbs = 12 lbs, costing $1.50 x 12 = $18.
Breaking the Ice.

Put the dry ice into a large sturdy bag, such as a rice bag. Handle the ice with gloves or with a dry towel.

Using a hammer, crush the dry ice with moderate blows until the pieces feel like they are smaller than golf balls.

Using a rubber mallet, if you have one, continue crushing the ice for a minute or so. You want the dry ice to be in powder form, but it is OK if some small chunks remain.

Pour the crushed ice back into the cooler. When it is time to dole out the dry ice, you can scoop it out with a cup from the cooler and pour into a bowl. Do not be too stingy. Students will need an ample bowlful to reliably see cosmic ray tracks. It is easy to scoop without gloves, but do not allow students do this themselves unless they are wearing gloves. Students can carry the bowl of dry ice back to their tables by holding the rim.

Consider providing students with gloves and with safety glasses if you have high standards about safety and protocols of safety or if you have some concerns about the maturity of your students.

Extracting the Radioactive Source.

Smoke detectors have a small radioactive source of americium 241, an alpha emitter with a half-life of about 400 years. For an excellent discussion of this topic, visit the following website: http://www.uic.com.au/nip35.htm

Open the plastic casing of the smoke detector.

Pull out the smoke detector panel. For this model, there were a few plastic tabs on the side, which you can pinch, and one plastic tab underneath which releases with a light pull.

Pull back the cover, shown in black here. There were some metal tabs underneath. Rip the cover of the radioactive source as shown.

Then rip out the metal source.
Observing Visitors from Outer Space

Refer to the instructions sheet for directions on how to build the cloud chamber and what to do with it.

Describe in detail what you observe for five to ten minutes. Begin your observations from the moment you place the cloud chamber on the ice. If you have lab partners, you may have to take turns viewing the cloud chamber and it may take more time overall. Take special note of any sounds, droplets, formation of clouds, movement of clouds, frost and any other interesting phenomena.

After this initial observation session, obtain an alpha source from your teacher and place it next to your cloud chamber. Watch the cloud chamber for at least 5 more minutes. Describe in detail any new observations.

Describe what you think is happening to alpha particles and to the alcohol vapor in the cloud chamber as these new observations occur.
You are now ready to investigate the arrival of visitors from outer space. Remove the alpha source and place it at least 1 meter away from your cloud chamber. Be patient. Be observant. Remember to get up close to your cloud chamber. Record any new observations.

Describe what you think is happening to the visitors from outer space and to the alcohol vapor in the cloud chamber as these new observations occur.

Describe 3 similarities between what is happening with the alpha particles and what is happening with the visitors from outer space.

Describe 3 differences between what is happening with the alpha particles and what is happening with the visitors from outer space.
Galactic cosmic rays (GCRs) are the high-energy particles that flow into our solar system from far away in the Galaxy. GCRs are mostly pieces of atoms: protons, electrons, and atomic nuclei which have had all of the surrounding electrons stripped during their high-speed (almost the speed of light) passage through the Galaxy. Cosmic rays provide one of our few direct samples of matter from outside the solar system. The magnetic fields of the Galaxy, the solar system, and the Earth have scrambled the flight paths of these particles so much that we can no longer point back to their sources in the Galaxy. If you made a map of the sky with cosmic ray intensities, it would be completely uniform. So we have to determine where cosmic rays come from by indirect means.

Cosmic Rays. Cosmic rays are energetic particles that are found in space and filter through our atmosphere. Cosmic rays have interested scientists for many different reasons. They come from all directions in space, and the origination of many of these cosmic rays is unknown. Cosmic rays were originally discovered because of the ionization they produce in our atmosphere. Cosmic rays also have an extreme energy range of incident particles, which have allowed physicists to study aspects of their field that cannot be studied in any other way.

In the past, we have often referred to cosmic rays as "galactic cosmic rays", because we did not know where they originated. Now scientists have determined that the sun discharges a significant amount of these high-energy particles. "Solar cosmic rays" (cosmic rays from the sun) originate in the sun's chromosphere. Most solar cosmic ray events correlate relatively well with solar flares.

Scientists have postulated that cosmic rays can affect the earth by causing changes in weather. Cosmic rays can cause clouds to form in the upper atmosphere, after the particles collide with other atmospheric particles in our troposphere. The process of a cosmic ray particle colliding with particles in our atmosphere and disintegrating into smaller pions, muons, and the like, is called a cosmic ray shower. These particles can be measured on the Earth's surface by neutron monitors.
Schematic Diagram of Cosmic Ray Shower
Observing Visitors from Outer Space
You will construct a device called a cloud chamber.
If you watch very carefully, you will observe visitors from outer space!

To begin making your cloud chamber, completely cover the base of a clear cup with silicone glue.
In this picture, the base is only partially covered so far.

Get your materials together.
- Approximately 10 cm x 10 cm of aluminum foil
- Approximately 15 cm x 15 cm of black plastic
- Clear cup with base completely covered with silicone glue
- 3 to 5 small cotton balls
- 2 thick rubber bands and 1 thinner rubber band

Your teacher will provide a radioactive source later on.
A small amount of Americium 241, an emitter of alpha particles and obtained from an ordinary smoke detector, serves as our radioactive source.
Radioactive "button" in the middle of this metal part.

These alpha rays are benign in that they are low in energy and do not penetrate your skin very well.
Nevertheless, use discretion when handling this or any other radioactive material.
Touch the source only as necessary.
Never ingest a radioactive source. Alpha rays emitted from inside your body certainly are harmful.

Push the cotton balls against the bottom so that they thoroughly stick to the glue.
Saturate the cotton balls with isopropyl alcohol (91%).

Pour out and lightly shake out any excess alcohol if it drips from the cotton balls.

Attach the piece of plastic bag by fitting a heavy rubber band around the cup.

Attach a second rubber band above the first. The two rubber bands create a tight seal.

Place the aluminum foil around the top. Then cut away the excess aluminum foil.

The foil distributes heat very well and offers a measure of protection to the plastic.

You are going to be using dry ice (solid carbon dioxide) in your experiment.

Dry ice is extremely cold, so use appropriate care when handling.

The dry ice has a temperature below \(-109.3^\circ F\) or \(-78.5^\circ C\).

It is possible to "burn" yourself or others severely if you are incautious or reckless.
Place your device upside down on a layer of crushed dry ice provided by your teacher.

Use a flashlight to view the clouds inside. It is usually easier to view the clouds from the same side as you illuminate it. Get very close to your cloud chamber (preferably within 20 centimeters). The closer the better.

Record what you observe for five to ten minutes. Begin your observations from the moment you place the cloud chamber on the ice. If you have lab partners, you may have to take turns viewing the cloud chamber and it may take more time overall. Take special note of any sounds, droplets, formation of clouds, movement of clouds, frost and any other interesting phenomena.

The surface of the plastic cup may eventually collect frost. This frost is a good thing and a bad thing. It's good because it means that the air inside the chamber is getting cold. It's bad because it obstructs your view. Use a paper towel occasionally to wipe away the frost.

After this initial observation session, obtain an alpha source from your teacher and place it next to your cloud chamber. Watch the cloud chamber for at least 5 more minutes. Record any new observations in your report.

You are now ready to investigate the arrival of visitors from outer space. Be patient. Be observant. Remember to get up close to your cloud chamber.