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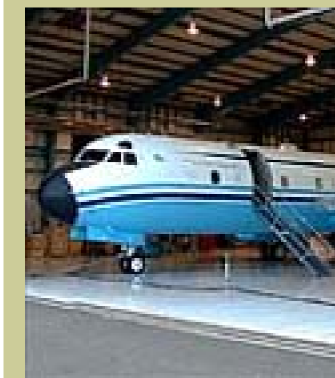
By MALCOLM W. BROWNE



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Tuesday, November 17, 1998

Constellation Prizes

Leonid Meteors and Making Comets in the Science Classroom

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Grades: 6-12

Subjects: Current Events, Science
Interdisciplinary Connections

Overview of Lesson Plan: In this lesson, students learn about meteors, meteorites, and comets by reading and discussing a related New York Times article about the Leonid meteor showers and the methods that scientists are using to learn from these meteors. Students then create and observe a comet in their classroom.
Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 1 hour

Objectives:
Students will:
1. Write a journal entry about meteors, comets, and their effects on the Earth and its atmosphere.
2. Define and discuss meteors, meteorites, meteoroids, and comets.
3. Read and discuss "Science Takes Its Seat for the Night of the Meteors."
4. Create a scientifically-accurate comet.
5. Log observations about the comet as it changes and heats in the classroom's atmosphere, and relate observations to known facts about comets in the Earth's atmosphere.

Resources / Materials:
classroom blackboard
pens/ pencils
student journals
paper
copies of "Science Takes Its Seat for the Night of the Meteors" (one per student)
ingredients for making a comet:
-5 pounds dry ice (frozen carbon dioxide)
-half gallon of water in pitcher or bottle
-a few drops of ammonia
-handful of dirt or fine sand
-a couple of drops of dark corn syrup, corn starch, or Worcester sauce
-3 or 4 trash bags
-large bowl or pot
-insulated work gloves (for handling dry ice)
-cloth towel
-hammer or mallet
-large mixing spoon
-paper towels (for clean-up)

Activities / Procedures:
1. WARM-UP/DO-NOW: Students respond to the following questions in their journals (written on the board prior to class):
--What is the scientific term for a "shooting star"?
--What is a comet?
--How could a meteor shower affect the Earth and its atmosphere?
Students then share their answers.

2. Students take notes on and discuss the definitions of the astronomical terms below. Students should share any examples of famous meteor showers and comets about which they know.
--meteor: a small solid body entering a planet's atmosphere from space and raised to incandescence by the friction resulting from its rapid motion.
(definition from Encarta Concise On-Line Encyclopedia)
--meteorite: a meteor that reaches the surface of the earth without being completely vaporized (definition from Merriam-Webster's On-Line Dictionary)
--meteoroid: a meteor particle itself without relation to the phenomena it produces when entering the earth's atmosphere; a meteor in orbit around the sun (definition from Merriam-Webster's On-Line Dictionary)
--comet: a celestial body that consists of a fuzzy head usually surrounding a bright nucleus, that has a usually highly eccentric orbit, and that often, when in the part of its orbit near the sun, develops a long tail which points away from the sun (definition from Merriam-Webster's On-Line Dictionary)

3. Students read and discuss "Science Takes Its Seat for the Night of the Meteors," focusing on the following questions:

--What reasons does the article give for satellites maneuvering into different positions?
--Why is the Leonid meteor shower expected on November 17, 1998, significant, if Leonid meteors fall every year around this time? What information can scientists learn from this year's meteors?
--Dr. Donald K. Yeomans is guessing "that the storm will be much more modest (than that which occurred in 1966), producing only 200 to 5,000 meteors per hour." Calculate the meteors per minute and per second based on these numbers.
--How are instruments on planes being used to learn about the meteors?
--Why are scientists "not worried about being hit by meteors"?
--Paragraphs 10- 14 discuss "the lead experiment on the Electra." What will this experiment measure, and how does the lidar instrument that this team created work? What do they hope to learn by using lidar instruments?
--Why is it important to "determine how a meteor's mass is related to its brightness"? What might this experiment tell us about meteors?
--How will scientists "learn whether meteor storms degrade the ozone shield protecting life on Earth from harmful ultra-violet radiation"? Why is this knowledge important?
--According to the last two paragraphs of the article, how have satellites been prepared for the meteor storm? What information do satellites offer, and why is it important to protect these satellites the best that we can from meteor showers?

4. Create a scientifically- accurate comet in the classroom. (Students can help with mixing ingredients.) The ingredients used are either actual components of comets or good representations of the actual components. The dry ice is frozen carbon dioxide. Water, ammonia, organic molecules (dirt or sand), and silicates (dark corn syrup, corn starch, or Worcester sauce) all exist on comet nuclei. During this experiment, ask students what these ingredients represent in real comets. The steps for creating the comet are as follows:
a. Line the mixing bowl with a trash bag, and set up all of the ingredients. Pour about a pint of water into the bowl. Add the corn syrup, corn starch or Worcester sauce, ammonia, and about half of the dirt or sand; mix well.
b. Put on the gloves. (The teacher should be the only one to handle the dry ice.) Wrap the dry ice in a cloth towel and place the bundle in the other trash bags, which should be placed inside each other. Hammer the dry ice into a powder.
c. Gradually pour the dry ice powder into the water, mixing as you pour. A lot of vapor will form, and the ingredients should form a slush.
d. Lift the bag lining the bowl enough to allow your gloved hands to pack the slush into a ball. Keep packing the mixture until the ball solidifies.
e. Peel back the trash bag from the ball, and scatter some more dirt over it. Pour the remaining water over the ball, turning it as you pour so that a layer of water ice forms over the entire ball.
The comet is now complete and can be handled without gloves if the water ice coating is intact. (Students should be encouraged, however, to use a stick or spoon rather than their hands.) The comet will hiss and pop as the carbon dioxide sublimes (or changes from its solid form of dry ice directly into a gas) and forces

its way through weak spots in the water ice crust. This is what happens when comets are heated by the Sun. On real comet nuclei this results in slight jetting that can cause the nucleus to spin, slightly alter its orbit, or split apart. After several hours, the comet will become filled with craters as the more volatile carbon dioxide sublimates before the water ice melts. Meteors, or fragments of comets, may also form.

5. WRAP-UP/HOMEWORK: During and after the creation of the comet, students should keep a log of all of their observations about the comet's appearance and "activities," sketching the comet each time they observe it and relating their observations to their knowledge of comets in the Earth's atmosphere. Encourage students to visit as often as they can (between classes, before and after school, during lunch, etc.), and observe the comet as a class until it is completely melted or fragmented.

Further Questions for Discussion:

--What is a meteor? What are meteorites and meteoroids?

--What are comets, and how are they related to meteors?

--Why is the Leonid meteor shower expected on November 17, 1998, significant, if Leonid meteors fall every year around this time? What information can scientists learn from this year's meteors?

--How are instruments on planes being used to learn about the Leonid meteors and other meteor showers?

--How have satellites been prepared for the Leonid meteor storm? What information do satellites offer, and why is it important to protect these satellites the best that we can from meteor showers?

--How could a meteor shower affect the Earth and its atmosphere?

Evaluation / Assessment:

Students will be evaluated based on journal entry, participation in class discussions, participation in comet-creation lab, and log of observations about the comet's appearance and "activities."

Vocabulary:

orbiting, maneuvered, astrophysicists, atmospheric, constellation, propulsion, spectroscopy, probes, elliptical, respective, triangulation, altitude, mesosphere, diode, wavelength, optical, ionized, nanometers, fluorescence, intervals, aeronautics, silicates, ozone, radiation

Extension Activities:

1. Study the layers of the Earth's atmosphere.

2. Diagram or create a model of our solar system, including comets and meteors.

3. Explore how light works by studying reflection, refraction, and waves.

4. Take a trip to a planetarium or ask an astronomer to speak to the class so that you can learn about constellations, planets, solar systems, and other celestial

bodies.

5. Use a chart of constellations to locate some constellations on a clear night.

6. Look at the night sky from a fixed spot once every few days over the course of a month or longer, and with the help of a book on constellations, chart what you see.

7. Read "Communication Satellites in Peril as Cosmic Storm Approaches" (by Seth Schiesel in the November 16, 1998, Business Day section of The New York Times) and write a response to how meteor showers could affect technology and business ventures in our atmosphere.

8. Find articles in newspapers, books or on the Internet that support or refute that meteor showers brought about the extinction of dinosaurs.

Interdisciplinary Connections:
Fine Arts- Find and discuss paintings with representations of heavenly bodies, such as Vincent Van Gogh's "Starry Night." How are these heavenly bodies represented in the paintings? How do these representations represent the society in which they were created?

Global History/ Social Studies/ Geography- Learn about examples of meteors crashing into the earth. Where did these impacts occur, and how did they affect the geography and life of the area?

Language Arts- Research the myths behind the names of constellations.

Mathematics- Conduct experiments using triangulation, referring to how triangulation is used in measuring the distance between meteorites. Students can also study units of measurement used in astronomy.

Media Studies- Watch and discuss "Armageddon" or "Deep Impact," two recent movies about meteors that are due to crash into Earth and how science is used to deflect and destroy or otherwise protect people on Earth. Students can also read articles about the Leonid meteor shower in Asian newspapers, as this area of the world will be able to see the meteors most clearly. (http://www.ecola.com) to locate English-language newspapers from Asian countries.

Technology- Learn about the design and function of satellites.

References: Encarta Concise On-Line Encyclopedia: (http://encarta.msn.com)
Merriam-Webster's On-Line Dictionary: (http://www.m-w.com)
Comet lab activities adapted from Educator's Guide to Kitchen Comets (ftp://ftp.jpl.nasa.gov/pub/educator/comets.txt) and Let's Cook Up a Comet! (http://whyfiles.news.wisc.edu/011comets/crecipe.html)

Additional Related Articles:
"As Meteors Near, Satellites Avert Eyes" (Malcolm Browne, 10/13/98)
"The Leonids: A Viewer's Guide" (Malcolm Browne, 10/13/98)

Other Information on the Web
Leonid Mission '98, the Leonid Multi-Instrument Aircraft Campaign's Web site, offers information about the Leonid mission, images and AVs, a teacher's corner with lesson plans, links, and resources. Go to http://www.leonids.arc.nasa.gov

Astronomy On-Line: The Leonids offers history of the yearly meteor shower from the constellation Leo. Visit the site at (http://www.eso.org/outreach/spec-prog/aol/market/collaboration/meteor/)

Leonid Storm Watch, the SETI Institute's site, discusses the Leonids, the SETI mission, and other interesting astronomy information. See (http://www.seti.org/leo.html)

The NASA Observatorium's Observation of the Week is the Leonid meteors. Visit (http://observe.ivv.nasa.gov/nasa/ootw/current/) for pictures, information, and links.

Media i Corporation's Milkyway Live Project offers a live display of the Milky Way from a mountaintop in Agawa, Japan. Astronomers expect that many Leonid meteors will be visible from November 13- December 13, 1998. Go to (http://www.media-i.com/www/Milkyway/index.html) to see this terrific site.

Academic Content Standards:

This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8
Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows the composition and structure of the Earth's atmosphere; Knows factors that can impact the Earth's climate
Science Standard 3- Understands essential ideas about the composition and structure of the universe and the Earth's place in it. Benchmark: Knows characteristics and movement patterns of asteroids, comets, and meteors
Science Standard 14- Understands the nature of scientific knowledge. Benchmark:

Knows that all scientific ideas are tentative and subject to change and improvement in principle, but for most core ideas in science, there is much experimental and observational confirmation
Science Standard 15- Understands the nature of scientific inquiry. Benchmarks: Knows that there is no fixed procedure called "the scientific method," but that investigations involve systematic observations, carefully collected, relevant evidence, logical reasoning, and some imagination in developing hypotheses and explanations; Designs and conducts a scientific investigation; Knows that observations can be affected by bias; Uses appropriate tools (including computer hardware and software) and techniques to gather, analyze, and interpret scientific data; Establishes relationships based on evidence and logical argument; Understands the nature of scientific explanations; Knows that scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists; Knows possible outcomes of scientific investigations
Science Standard 16- Understands the scientific enterprise. Benchmarks: Knows that people of all backgrounds and with diverse interests, talents, qualities, and motivations engage in fields of science and engineering; some of these people work in teams and others work alone, but all communicate extensively with others; Knows that the work of science requires a variety of human abilities, qualities, and habits of mind; Knows various settings in which scientists and engineers may work; Knows ways in which science and society influence one another
Technology Standard 3- Understands the relationships among science, technology, society, and the individual. Benchmarks: Knows that scientific inquiry and technological design have similarities and differences; Knows that science cannot answer all questions and technology cannot solve all human problems or meet all human needs; Knows ways in which technology has influenced the course of history; Knows that technology and science are reciprocal; Knows ways in which technology and society influence one another

Grades 9-12
Science Standard 3- Understands essential ideas about the composition and structure of the universe and the Earth's place in it. Benchmark: Knows ways in which technology has increased our understanding of the universe
Science Standard 14- Understands the nature of scientific knowledge. Benchmarks: Knows ways in which science distinguishes itself from other ways of knowing and from other bodies of knowledge; Understands how scientific knowledge changes and accumulates over time; Knows that from time to time, major shifts occur in the scientific view of how the world works, but usually the changes that take place in the body of scientific knowledge are small modifications of prior knowledge
Science Standard 15- Understands the nature of scientific inquiry. Benchmarks: Knows that a wide range of natural occurrences may be observed to discern patterns when conditions of an investigation cannot be controlled; Knows that conceptual principles and knowledge guide scientific inquiries-- historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other

scientists; Knows that scientists conduct investigations for a variety of reasons Science Standard 16- Understands the scientific enterprise. Benchmarks: Understands that individuals and teams contribute to science and engineering at different levels of complexity; Understands that science involves different types of work in many different disciplines; Knows that creativity, imagination, and a good knowledge base are all required in the work of science and engineering Technology Standard 3- Understands the relationships among science, technology, society, and the individual. Benchmarks: Knows examples of advanced and emerging technologies; Knows that mathematics, creativity, logic, and originality are all needed to improve technology; Identifies the role of technology in a variety of careers

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