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ABSTRACT
This teacher's guide is designed to accompany the PBS television program "NOVA." Six science activities correspond to: (1) "Lost at Sea: The Search for Longitude," which researches and charts the shortest course to circumnavigate the globe; (2) "Chasing El Nino," which formulates a question and designs an experiment to evaluate the accuracy of weather folklore; (3) "Terror in Space," which explores the concept of center of mass and experiments with how altering the location of an object's center of mass can affect its motion; (4) "Special Effects: Titanic and Beyond," which investigates how geometry plays a role in perspective; (5) "Deadly Shadow of Vesuvius," which collects data and creates maps to observe the relationship between volcanoes, earthquakes, and lithospheric plates; and (6) "Ice Mummies," which investigates the rate of microbial growth at different temperatures, and analyzes and interprets information in order to locate an archaeological site. All activities include a list of the National Science Education Standards addressed. (YDS)
As an educator, you deal with the future on a daily basis. More than that – you deal with it on a first-name basis. Every Lisa and Michael and Maria and Tyrone is a representative of future generations to be touched and inspired by your gift for teaching.

I understand how important you are to the future. Because at Northwestern Mutual Life, the future is our business, too: every day, we’re helping people make personal and financial plans that will serve them well throughout their lives.

From one future-watcher to another, it is a pleasure to present you with the fall issue of the NOVA Teacher’s Guide. I think you’ll find this season’s offerings to be rich with stimulating material for your classroom. And as proud sponsors of this award-winning educational television series, everyone here at Northwestern Mutual Life thanks you for your dedication to shaping the future.

James D. Ericson
President and Chief Executive Officer
25 Years and Still Going
Join us in celebrating 25 years of NOVA and discover what we're changing to make it easier for you to use NOVA in the classroom.

NOVA in the Classroom
Learn about how 25 teachers around the country are using NOVA, how you can share lesson ideas, and the next NOVA/PBS Online adventure coming your way.

Lost at Sea: The Search for Longitude*
Week of October 6

Chasing El Niño*
Week of October 13

The Day the Earth Shook* (R)
Week of October 20

Terror in Space*
Week of October 27

Special Effects: Titanic and Beyond*
Week of November 3

Deadly Shadow of Vesuvius*
Week of November 10

Flood!* (R)
Week of November 17

Ice Mummies* (3-Hour Special)
Frozen in Heaven
Siberian Ice Maiden
Return of the Iceman
Week of November 24

Leopards of the Night*
Week of December 1

Plague Fighters* (R)
Week of December 8

Supersonic Spies* (R)
Week of December 15

Venus Unveiled** (R)
Week of December 22

The Perfect Pearl*
Week of December 29

NOVA Video Catalog

Because of schedule changes and space constraints, some NOVA programs do not have lessons.

* one-year off-air taping rights
** seven-day off-air taping rights
(R) indicates a repeat program from a previous NOVA season.

Lesson within this guide.
Lesson online at: http://www.pbs.org/nova/teachers/teachersguide.html
Dear Educators,

This season marks NOVA’s 25th anniversary in science programming and education. As the highest-rated year-round series on the PBS prime-time lineup, NOVA has defined science television for the United States and the world. Each program is watched by an average of 30 million people a month. NOVA’s films are seen by viewers in more than 50 countries, from Australia to Zimbabwe. This guide is sent to more than 80,000 teachers. We are grateful for everything you do to help students discover the rewards of science.

Since our birth 25 years ago, NOVA has evolved to meet the ever-changing, rapidly-expanding needs of our viewers. Never before have our lives been so intimately linked with science and technology nor has knowledge held so much power. Our goal is to bolster and promote science literacy in the best way we know how through a variety of mediums: television, NOVA Online, and print, most notably the Teacher’s Guide.

We have taken the opportunity of this anniversary season to revise the NOVA Teacher’s Guide to help bring you and your students into next century’s world of science education. For each program, you’ll find an expanded lesson that now includes:

- a video overview that more closely defines program content;
- alignment to the National Science Education Standards;
- ideas for before and after watching to help you understand prior student knowledge, reacquaint you with the program’s geographical locations, and prepare students for the program’s content;
- activity setup instructions for you, including a materials list and extension ideas;
- reproducible student activity pages to guide students through each activity;
- explanations of each activity’s outcome, with information to help you answer student questions; and
- annotated resources, including books, articles and Web sites.

To accommodate the added material, we have more than doubled the space for our lesson plans. We hope that you like the changes we’ve made. We look forward to bringing you NOVA for the next 25 years and beyond.

Paula S. Apsell
NOVA Executive Producer
Check Out Our Teachers Site
http://www.pbs.org/nova/teachers

Sign Up for Weekly Updates
Would you like to know what’s coming up on NOVA each week, both on television and the Web site? Join our mailing list and find out. Each week we’ll send you a reminder of the date and title of the following week’s broadcast, and what you’ll find online to help you integrate the Web into your curriculum. And we’ll keep you abreast of any special programs or online adventures we’re planning. Sign up at the Web site above.

Visit Us at NOVA Online!
Find Web Sites for Each New Program
NOVA Online brings you new content each week throughout the Fall season. See each lesson in this guide for details or visit our Web site at: http://www.pbs.org/nova

Participate in the Fall NOVA/PBS Online Adventure
Island of the Sharks
http://www.pbs.org/nova/cocos
Join noted underwater filmmakers as they dive into the waters of the Pacific Ocean’s Cocos Island to shoot an IMAX/OMNIMAX® film on the biodiversity, ecosystem and conservation aspects of the island. For one month, NOVA will update the Web site with digital dispatches and images. Launch date: September 23, 1998
NOVA in the Classroom

NOVA’s 25 Classrooms

As NOVA celebrates its 25th anniversary and looks ahead to the next 25 years, the NOVA education team is kicking off an initiative to make its classroom materials more effective. We’ve called on 25 middle and high school teachers to help us reach this goal.

This means you will:

• receive materials evaluated by teachers like yourself. Our nationwide group of NOVA teachers will provide in-depth feedback on our programs, teacher’s guide lessons, and Web sites. Their ideas—as well as those from our long-standing local teacher advisory board—will help us revise current materials and shape new ones.

• have additional NOVA ideas and projects from which to choose. Each NOVA teacher will develop a special project using NOVA resources—including in-service workshops, articles about NOVA, or multimedia lesson plans.

• learn how you can be involved in the NOVA Challenge. This Web event—designed especially for your students—will be held during National Science and Technology Week in April 1999. Questions for the challenge will be based on content from the 1998–99 season of NOVA programs and NOVA Online sites, and will promote active viewing and learning of science concepts. Look for hints and questions on NOVA Online throughout the year to help prepare your students. Winners will be chosen in a random drawing. Prizes will be awarded.

NOVA Videos 50% Off

In celebration of NOVA’s 25th season, we’re offering educators a special on all of our NOVA videos: 50 percent off on orders received by June 30, 1999. In addition, teachers who fill out and send back the business reply card in this guide will be entered into a drawing to win a free one-hour NOVA video of their choice. See page 40 for details.

NOVA Teachers’ Guides and on NOVA Online:
www.pbs.org/nova
When sixth-grade social studies teacher Tim Matthews decided he wanted to teach an interdisciplinary unit on ancient civilizations, he used the Spring 1997 NOVA Teacher's Guide to jump-start his thinking. The guide featured lessons to accompany the four-part series "Secrets of Lost Empires," and focused on the social studies aspects of ancient civilizations and the use of simple machines to raise massive objects such as Stonehenge's trilithons or the Egyptian obelisks.

Matthews worked with fellow science, mathematics and English teachers at Day Middle School in Newton, Massachusetts, to devise a plan: The teachers would introduce their 90 students to simple machines, scale and measurement, Egyptian history, and hieroglyphics during their 45-minute team period, scheduled four days a week.

In "Operation Obelisk: How Will We Raise the Obelisk?" students were asked to use any of six simple machines they learned about to develop a plan for raising a wood-frame 27-foot obelisk in the school courtyard. Students were to include an accurate drawing of how their simple machine would work, a description of how the obelisk would be raised, and a list of the materials needed.

As with any new unit, some goals were met more successfully than others. Matthews, who hopes to do the unit again, said next time he would simplify the number of concepts being taught. As assessment tools, Matthews created a process rubric to evaluate understanding of math terminology, building terms and abilities with manipulatives; and a product rubric for students to chart their own learning.

Matthews found out about the NOVA Teacher's Guide through copies passed down by a former teacher, and has now signed up for his own free subscription. "The benefit of the guide for me," he said, "is that it makes connections that I might not necessarily have made."

For your free subscription to this semiannual guide, please send us a note with your name, address, and the grades and subjects you teach to:

NOVA Teacher's Guide
WGBH, 125 Western Avenue
Boston, MA 02134
E-mail: WGBH_Materials_Request@wgbh.org

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We'd like to hear from YOU! Tell us how you're using a NOVA program or NOVA Online in your classroom. Write up your ideas at:

http://www.pbs.org/nova/teachers/teacherex.html

and we'll post them in our Lesson Ideas section. Or send your ideas to:

Jenny Lisle
WGBH, 125 Western Avenue
Boston, MA 02134

If we choose to feature your classroom in the NOVA Teacher's Guide, we'll send you and your students six free NOVA videos or two Classroom Field Trip kits of your choice.
NOVA chronicles the seventeenth-century journey to determine longitude.

- In 1714, following a maritime disaster, British Parliament offers £20,000 for the first reliable method of determining longitude on a ship at sea.

- It is known that longitude can be found by comparing a ship’s local time to the time at the port of origin. The challenge is finding a clock—a chronometer—that can keep time at sea, where temperature changes, humidity, gravity and a ship’s movement affect accuracy.

- Early attempts are based on the assumption that astronomy can solve the problem.

- Self-taught clockmaker John Harrison believes the answer lies in large mechanical clocks. Through careful observation and experimentation, he invents many adaptations to improve clock accuracy. After decades of work, he realizes pocket watches are a better choice and redirects his efforts to pursue this smaller technology.

- In 1764, Harrison’s watch proves accurate in helping determine the longitude on a six-week voyage to Barbados.

Portrait of John Harrison, a self-taught clockmaker.
of the international date line). Have students find a way to make the lines equiangular (for example, they might cut the orange in half and use a protractor to mark equiangular segments). Have students approximate where their city is on the fruit model of the Earth and then confirm latitude and longitude using a map.

Objective
To research and chart the shortest course to circumnavigate the globe.

Materials for each group
- copies of the Voyage Around the World activity sheets on pages 8–9
- world map, globe or atlas, with a scale
- small tacks, pins or self-stick notes (for marking locations)
- a 12-inch piece of string (for measuring distances)

Procedure
1 Organize students into groups and distribute activity sheets and materials to each group. Explain that the challenge is to research and chart a course that takes them to each Checkpoint Destination on their way around the world once. Have students review the Nautical Rules and Checkpoint Destinations before beginning. (You may delete or change Checkpoint Destinations to best suit your students’ abilities.)

2 Have students research locations that match the Checkpoint descriptions, plot these locations on a map, record the latitude and longitude for each, and plan their course from one location to the next. Then have them estimate the distance between locations, using the string and a map scale.

3 When teams have completed their routes, have them exchange maps and recording charts to compare Checkpoint locations and estimated distances. Then, as a class, come up with the shortest route possible.

4 As an extension, you can have students convert the estimated distances from statute miles to nautical miles.

The activity found on pages 8–9 aligns with the following National Science Education Standards and Curriculum and Evaluation Standards for School Mathematics.

Grades 5–8

Science
Standard 6: History and Nature of Science
Science as a human endeavor
Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill and creativity—as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas.

Mathematics
Standard 7: Computation and Estimation

Mathematics
Standard 13: Measurement

Grades 9–12

Science
Standard 6: History and Nature of Science
Science as a human endeavor
Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem.
You are about to embark on a voyage around the world. Your mission is to chart a course that will take you to each Checkpoint Destination on your way around the globe once. Bon voyage!

**Materials for your group**
- world map, globe, or atlas, with a scale
- small tacks, pins or self-stick notes (for marking locations)
- a 12-inch piece of string (for measuring distances)

**Procedure**

1. **Read the Nautical Rules.**
2. **Review the Checkpoint Destination descriptions.** Research and find locations that match each Checkpoint, which you must visit in order. Your goal is to visit every Checkpoint and circumnavigate the globe.
3. **On a world map, globe or atlas mark the locations you’ve chosen for each Checkpoint. Record the location and its latitude and longitude for each Checkpoint.**
4. **Plan a course from one Checkpoint to the next and estimate the distance between each location, using the string and map scale. Then calculate the total distance for the entire voyage.**
5. **Trade recording charts with another team and check that team’s course and distance measurements.**
6. **Once you have checked another team’s course, work as a class to chart the shortest course around the world.**

**Nautical Rules**

- Begin and end your trip in Greenwich, England.
- Circumnavigate the globe once.
- Visit every Checkpoint Destination. (Each Checkpoint must be a different location.)
- Visit the Checkpoints in order.
<table>
<thead>
<tr>
<th>Checkpoint Destination</th>
<th>Location</th>
<th>Latitude and Longitude</th>
<th>Estimated Distance from Previous Checkpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Start in Greenwich, England.</td>
<td>Greenwich, England</td>
<td>51°29'N, 0°00'W</td>
<td>0 miles</td>
</tr>
<tr>
<td>2 Dodge an iceberg.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Dock next to a cruise ship.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Stop at a Spanish-speaking port.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Stop at an English-speaking port.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 View a high mountain from a port.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Visit a major oil-supplying port.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Photograph a kangaroo.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Sight a penguin.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Collect exotic spices.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Have lunch in a country where rice is a dietary mainstay.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Visit a country that has changed its name within the past 50 years.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 End in Greenwich, England.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Distance

12
Activity Answer

Because the Checkpoint Destinations are open-ended, the locations and courses students choose will vary (see sample course below). When students present their locations, courses and estimated distances, they should be able to explain why each location matches the Checkpoint description, how they chose the course, and the method they used for estimating distances. Most maps students will be using show statute miles, the unit of measurement for distances on land. Distances at sea are measured in nautical miles. A nautical mile is found by dividing the Earth into 360 degrees, and then dividing each degree into 60 minutes. One nautical mile equals one minute, or 1/21,600 of the Earth’s circumference. Students can convert statute miles to nautical miles by dividing the number of statute miles by 1.1508.

Sample Course

<table>
<thead>
<tr>
<th>Checkpoint Destination</th>
<th>Location</th>
<th>Latitude and Longitude</th>
<th>Estimated Distance from Previous Checkpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Start in Greenwich, England.</td>
<td>Greenwich, England</td>
<td>51°29' N, 0°00' W</td>
<td>0 miles</td>
</tr>
<tr>
<td>2 Dodge an iceberg.</td>
<td>Reykjavik, Iceland</td>
<td>64°00' N, 21°56' W</td>
<td>1,230 miles</td>
</tr>
<tr>
<td>3 Dock next to a cruise ship.</td>
<td>St. Thomas, U.S. Virgin Islands</td>
<td>18°20' N, 64°55' W</td>
<td>4,010 miles</td>
</tr>
<tr>
<td>4 Stop at a Spanish-speaking port.</td>
<td>Panama Canal</td>
<td>9°10' N, 79°37' W</td>
<td>1,540 miles</td>
</tr>
<tr>
<td>5 Stop at an English-speaking port.</td>
<td>Los Angeles, California</td>
<td>34°00' N, 118°15' W</td>
<td>3,700 miles</td>
</tr>
<tr>
<td>6 View a high mountain from a port.</td>
<td>(Mt. Rainier) Seattle, Washington</td>
<td>47°35' N, 122°20' W</td>
<td>1,540 miles</td>
</tr>
<tr>
<td>7 Visit a major oil-supplying port.</td>
<td>Valdez, Alaska</td>
<td>61°07' N, 146°17' W</td>
<td>1,230 miles</td>
</tr>
<tr>
<td>8 Photograph a kangaroo.</td>
<td>Sydney, Australia</td>
<td>33°55' S, 151°10' E</td>
<td>9,560 miles</td>
</tr>
<tr>
<td>9 Sight a penguin.</td>
<td>Balleny Islands, Antarctica</td>
<td>66°30' S, 163°00' E</td>
<td>2,470 miles</td>
</tr>
<tr>
<td>10 Collect exotic spices.</td>
<td>Jakarta, Indonesia</td>
<td>6°09' S, 106°49' E</td>
<td>4,320 miles</td>
</tr>
<tr>
<td>11 Have lunch in a country where rice is a dietary mainstay.</td>
<td>Singapore</td>
<td>1°17' N, 103°51' E</td>
<td>620 miles</td>
</tr>
<tr>
<td>12 Visit a country that has changed its name within the past 50 years.</td>
<td>Sri Lanka (Ceylon)</td>
<td>7°30' N, 81°50' E</td>
<td>1,540 miles</td>
</tr>
<tr>
<td>13 End in Greenwich, England.</td>
<td>Greenwich, England</td>
<td>51°29' N, 0°00' W</td>
<td>8,020 miles</td>
</tr>
</tbody>
</table>

Total Distance 39,780 (statute miles) 34,567 (nautical miles)

Resources

Books

Sobel, Dava. Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time. New York: Walker, 1995. Takes the reader back to the maritime world of 1714, when finding the solution to the problem of determining longitude at sea was of the highest scientific, political and economic priority.

Web Sites
NOVA Online—Lost at Sea: The Search for Longitude http://www.pbs.org/nova/longitude/
Will include an interactive game that provides a way to understand why knowing the time at your home port allows you to fix your longitude at sea. The site will also feature how the Global Positioning System works, a time line of ancient navigation, and contributions from leading experts on what they believe are some of the greatest scientific challenges of our day.
Launch date: October 6, 1998.
NOVA examines the effects of past and present El Niños on global weather and follows the work of scientists who are trying to understand and predict this phenomenon.

- Scientists use computer models to describe the climate cycle that produces El Niño.
- In 1984, the National Oceanic and Atmospheric Administration (NOAA) begins building the Tropical Atmosphere Ocean (TAO) array, a network of buoys that measure surface winds, surface temperature, upper ocean temperature and ocean currents. By 1994, the first El Niño early warning system is in place.
- Scientists are unable to predict the '82-'83 El Niño due to a volcanic eruption that obscures the vision of satellites, falsely lowering the readings of sea surface temperatures by a few degrees.
- With the help of data collected by the TAO array, scientists forecast the oncoming of the '97-'98 El Niño. Even so, predictions do not accurately project the magnitude and rapid development of this El Niño.
- By flying a plane into a storm, meteorologists collect data on wind speed, temperature, rainfall and atmospheric pressure. They use this information to forecast where the storm’s precipitation will fall.

Drifter buoys are part of the TAO array, which measures variables such as atmospheric pressure, air and sea temperature, wind speed and wind direction.

Before Watching

1 El Niño is a term originally used to describe the warm surface current that usually appears every three to seven years in the Pacific Ocean along the coasts of Peru and Ecuador. On a world map, have students locate the Pacific Ocean, Peru and Ecuador.

2 A change in ocean temperatures and atmospheric conditions produces El Niño, which affects weather worldwide. Discuss with students the relationship between weather (atmospheric conditions at a given time and place) and climate (average weather conditions for an area over an extended period of time). Have students explain what they think is meant by the adage, “Climate is what you expect. Weather is what you get.”

3 As they watch, have students record various ways weather is affected during El Niño years and how these changes in weather impact specific regions.

After Watching

1 Have students review their notes and discuss some of the positive and negative effects of El Niño on world weather. In response to the '82-'83 El Niño, scientists have been collecting data, comparing this data to world weather events, and building computer models to help predict future El Niños. Discuss how people might use this information.
Objective
To formulate a question and design an experiment to evaluate the accuracy of weather folklore.

Materials for each group
- copies of the Forecasting Folklore student activity sheets on pages 13–14

Procedure
1. Ask students what they know about weather folklore and if they've ever heard any folklore that predicts weather. Generate a list of folklore sayings from those that students already know and from those that students collect by surveying their family and friends (a starter list can be found on page 14). Encourage students to survey people from older generations.

2. Organize students into pairs or small groups and distribute the activity sheets. Review sayings that students have generated as a class and discuss which of those might be proved or disproved by a controlled experiment or by observation and comparison. Have students select a saying that they think is possible to investigate. Students will use the guiding questions on the activity sheets to help them formulate a question and design an experiment to evaluate the accuracy of that saying.

3. To help students consider what makes an investigable question you may want them to consider why the following questions do or do not work:
   - Do crickets chirp faster when it is warmer and slower when it is cooler? (difficult to investigate because experimenter doesn’t know what’s warm or cold to a cricket)
   - Do crickets in the schoolyard chirp faster when the temperature is higher or lower? (investigable question)
   - Why do crickets chirp at different speeds? (most “why” questions are difficult to investigate)

4. Once students have completed their experiments, have them present their experimental design to the class and have class members predict what they think was found. Then have the presenting team share its data and have class members interpret it. Finally, have team members share their results to the class, explain how they arrived at their conclusions, and discuss any differing opinions.

5. As an extension, students can research additional data that supports or contradicts their experimental findings and research why certain folklore sayings are more accurate than others.

Standards Connection
The activity found on pages 13–14 aligns with the following National Science Education Standards.

Grades 5–8

Science Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
  - Identify questions that can be answered through scientific investigations.
  - Design and conduct a scientific investigation.
  - Use appropriate tools and techniques to gather, analyze and interpret data.
  - Develop descriptions, explanations, predictions and models using evidence.
  - Think critically and logically to make the relationships between evidence and explanations.
  - Recognize and analyze alternative explanations and predictions.
  - Communicate scientific procedures and explanations.

Grades 9–12

Science Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
  - Identify questions and concepts that guide scientific investigations.
  - Design and conduct scientific investigations.
  - Formulate and revise scientific explanations and models using logic and evidence.
  - Recognize and analyze alternative explanations and models.
  - Communicate and defend a scientific argument.
Centuries before meteorologists had advanced technology for making weather forecasts, people observed the natural world and looked for patterns to help explain and predict weather. Many of these observations were turned into sayings and passed down through generations. For example, “The louder the frog, the more the rain,” or “A sunny shower won’t last an hour.” But how accurate is weather folklore? Find out by designing an experiment that puts it to the test.

A cow with its tail to the west makes weather best; a cow with its tail to the east makes weather the least.

When ants travel in a straight line, expect rain; when they scatter, expect fair weather.

Guiding Steps and Questions
Use these steps to help you design your experiment.

1 Select a Folklore Saying
- Evaluate whether the folklore saying can be tested through scientific investigation.
- What constraints must you consider (such as availability of time and space, limitations of equipment, cost, safety issues)?

2 Create a Question
- Change the folklore saying into a question that can be answered through scientific investigation.
- What do you predict will be the answer to your question and why?
Chasing El Niño!

When leaves show their backs, it will rain.

3 Design the Experiment
- Identify the variables in the experiment.
- What kinds of data will help you answer your question?
- What data will you use to support your prediction?
- How will you collect, record and represent your data?
- What materials will you need?
- What steps will you take to carry out the experiment?

4 Review the Experimental Design
- Have another team review your experimental design. What questions do they raise and how might you address them? If there is any part of your experiment you are having a problem with, ask the other team for input or advice.
- Have your teacher review and approve your experiment before proceeding.

5 Do the Experiment
- Record the actual steps you take to carry out the experiment.
- Record your data.

6 Analyze the Data
- What patterns do you see in the data?
- How do you interpret the data?
- What evidence supports your interpretation?
- What might be inaccurate about your interpretation?
- How else can you explain the data?

7 Reflect on Your Experiment
- How can you organize the data to present the strongest explanation for your conclusion?

8 Share Your Findings and Interpretations
- First share your experimental design and then have your fellow classmates predict what they think you found.
- Next, share your data with them and have them try and interpret what you found.
- Finally, share your own conclusions and discuss any differing views as a class.

A Sample of Weather Folklore
- Red sky at night, sailors delight. Red sky in the morning, sailors take warning.
- The louder the frog, the more the rain.
- A sunny shower won't last an hour.
- When doors and windows stick, it will probably rain.
- A wind from the south has rain in its mouth.
- Haloes around the sun or moon indicate a rain or snow real soon.
- When a cow endeavors to scratch his ear, it means a rain shower is very near. When he thumps his ribs with an angry tail, look out for thunder, lightning and hail.
- Crickets are accurate thermometers; they chirp faster when warm and slower when cold.
- High clouds indicate fine weather will prevail; lower clouds mean rain.
- When clouds look like rocks and towers, the Earth will be refreshed by showers.
Activity Answer
The main objective is for students to design a sound scientific investigation. Before students begin, you might want to review their questions and experimental designs to ensure that they can complete the experiment within classroom constraints.

Most of the sayings lend themselves to observation and comparison. Any of these sayings could be proved or disproved, depending on the factors students choose to use as measures. Different students might use different factors. For example, in the saying “High clouds indicate fine weather will prevail; lower clouds mean rain,” a student who uses bright sunshine as a measure of fine weather might find the saying accurate, while a student who uses temperature over 65°F as a factor might find the saying inaccurate. Discuss with students the importance of choosing factors that are valid measures.

After students present their conclusions, discuss why some folklore sayings seem to be more accurate than others. In general, folklore that takes into account factors such as atmospheric conditions, shape and movement of clouds, and direction and force of winds can have accurate forecasting results for specific localities. In addition, sayings that are based on scientific principles are reliable. Folklore that refers to animals, birds, and insects is sometimes—but not usually—accurate. Whether a folklore saying is accurate or not has a lot to do with the locality. A folklore saying that works in one region may be entirely inaccurate in another region.

Resources
Books

Articles


Web Sites
NOVA Online—Tracking El Niño
http://www.pbs.org/nova/elnino/
This Web site, a NOVA/PBS Online Adventure launched in Winter 1998, includes information about the anatomy and reach of El Niño. Archived dispatches of scientists’ efforts to track El Niño will be updated with information on how those predictions stacked up to what actually happened with this powerful weather phenomenon. Launch date: October 13, 1998.

NOAA El Niño Page
http://www.elnino.noaa.gov/
Provides current El Niño status reports, fact sheets, a web tour of the TAO buoy array and more.

American Weather Folklore
http://www.athena.ivy.nasa.gov/curric/weather/sweathr/solutions.html
Reviews the validity of 14 different weather folklore sayings.

Weather-Related Sites
http://www.athena.wednet.edu/curric/weather/sweathr/links.html
Contains a comprehensive chart of weather-related sites.
NOVA looks at life on the Russian space station Mir and investigates the recent series of mishaps that the station has encountered.

- Launched in 1986, Mir's projected lifespan is five years. However, Mir continues to be used into the late 1990s.
- In 1995, American astronauts join Russian cosmonauts on Mir to study long-term endurance in space.
- During an exchange-of-astronauts celebration, a fire is discovered shooting from an oxygen canister, turning the festivities to panic. Russians and Americans disagree over the seriousness of the situation.
- Cosmonauts and astronauts struggle to repair and maintain the station's aging technology.
- While practicing a manual docking procedure, cosmonauts lose control of an unmanned supply ship, which crashes into the space station, causing the cabins to depressurize and damaging the station's solar panels.

Mir has hosted seven U.S. astronauts who have conducted studies in areas such as photo documentation in changes of the Earth's surface, the growth of three-dimensional cancer cells, International Space Station mitigation, and the effects of long duration space flight on the human body.

Before Watching
1. Astronauts were sent to Mir to help scientists understand some of the effects of living in space for extended periods of time. Ask students what they think are some of the challenges of living in space (such as weightlessness, close living quarters, boredom). As they watch, have students note the challenges faced by the Mir crew.

After Watching
1. Have students review their notes and discuss the challenges faced by the Mir crew. What incidents arose as a result of technical failures or error? What issues occurred as a result of cultural and political differences between the Russians and Americans? Discuss possible challenges and solutions that might arise in the International Space Station, which will be shared by 16 nations.
2. Have students compare Mir with the space station on “Deep Space Nine” or with other popular science-fiction space stations. What are the similarities and differences?
3. Ask students to support or refute the idea that from space, Earth seems like a single community.
Objective
To explore the concept of center of mass and experiment with how altering the location of an object's center of mass can affect its motion.

Materials for each group
Part I
- copies of the Controlling the Cube student activity sheet on page 18
- 1 Styrofoam ball
- weights: pennies, washers or marbles
- tape

Part II
- copies of the NOVA Cube Template on page 19, photocopied on card stock
- scissors
- tape
- self-stick notes
- 1.3-centimeter (0.5-inch) cube of modeling clay

Procedure
For Part I, organize students into pairs and distribute the activity sheets and materials. Have students roll a Styrofoam ball across a table to a partner and observe the ball's path and motion. Encourage students to experiment with varying the force with which they roll the ball. Then have students add a weight to alter the location of the ball's center of mass, and have them roll and observe the ball again. Discuss how this activity relates to the behavior of the supply ship Progress as it attempted to redock with Mir.

For Part II, distribute the NOVA Cube Template and clay. Have students cut out and assemble the cube. Students will experiment to determine the probability of a certain side of the cube landing face-up when the location of the center of mass is in the center of the cube, and again when it is off-center.

For their main challenge, have students find how best to position the clay so that when they roll their cube, the NOVA logo appears face up the most often. Have them predict before experimenting. Once students have completed their experiments, have them present their results to the class and explain why they think their strategy worked.

The activity found on page 18 aligns with the following National Science Education Standards and Curriculum and Evaluation Standards for School Mathematics.

Grades 5–8

Science
Standard B: Physical Science
Motions and forces
- The motion of an object can be described by its position, direction of motion and speed. That motion can be measured and represented on a graph.
- An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.
- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

Mathematics
Standard 11: Probability

Grades 9–12

Science
Standard B: Physical Science
Motions and forces
- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship \( F = ma \), which is independent of the nature of the force.
Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Mathematics
Standard 11: Probability
Controlling the CUBE

One theory about why the supply ship Progress crashed into Mir was its center of mass was not centered, making the ship move unpredictably. See what happens when you change the location of an object's center of mass. Then see if you can alter the location of an object's center of mass to make the object move the way you want.

Part I
Materials for your group
- 1 Styrofoam ball
- weights: pennies, washers or marbles
- tape

Procedure
1 Roll the Styrofoam ball across the table to your partner. Experiment with using different amounts of force. What do you observe about the ball's path and motion?
2 Insert a weight into the Styrofoam. Secure the weight with tape, if necessary.
3 Predict what will happen when you roll the ball this time.
4 Roll the ball again. Experiment with using different amounts of force. What do you observe about the ball's path and motion?

Questions
Write your answers on a separate sheet of a paper.
1 What happens to the motion of the ball, with and without the weight? Explain the similarities and differences you observed.
2 How does this activity model the behavior of the Progress as it attempted to redock with Mir?

Part II
Materials for your group
- copy of the NOVA Cube Template
- scissors
- tape
- self-stick notes
- 1.3-centimeter (0.5-inch) cube of modeling clay

Procedure
1 Assemble the cube, folding the edges carefully so they align as accurately as possible. Use the same size piece of tape on all sides (even the folded side). Cut out a small piece of self-stick note to hold down the lid.
2 Roll your cube 30 times and record how often each side lands facing up.
3 Assuming a cube has uniform sides and its center of mass is located at the “center” of the cube, the theory of probability states that each side has a 1 in 6 chance of landing face-up. Combine your data with data from other teams, and compare the class's results with the theoretical probability.
4 Now alter the location of your cube's center of mass by placing clay on one of the interior sides of the cube. How can you position the clay so that when you roll your cube, the NOVA logo appears face up the most often? The team that rolls the most NOVA logos in 30 rolls becomes the center of mass master!
NOVA Cube Template

Photocopy NOVA Cube Template on card stock.
Activity Answer

This lesson focuses on objects that are caused to rotate by some outside force. All objects in free fall (such as thrown balls and space ships in orbit) tend to rotate around their center of mass. When the center of mass doesn’t coincide with the “center” of the object, the object’s behavior becomes erratic, or “wobbly.” Students should notice in Part I that the path and motion of the ball with added weight is erratic.

Unbalanced forces will cause the speed and/or direction of an object’s motion to change. As students increase the force with which they roll the weighted ball, they will also notice that the ball’s motion becomes increasingly erratic. This is essentially due to the fact that the frequency and amplitude of the “wobble” is greater if an object is moved with more force—thus making the motion seem more erratic. This activity models the behavior of the Progress as the cosmonauts attempted to redock it. Since the garbage was loaded off-center, the location of the supply ship’s center of mass was no longer along its center axis. As the Progress was accelerated through space, the unbalanced center of mass possibly made the ship’s motion increasingly erratic as it approached Mir.

In Part II, the theoretical probability that any one side of a cube will land face-up is 1 in 6 (assuming a cube has uniform sides and its center of mass is located at the “center” of the cube). When students add clay to the inside of the cube, the center of mass is no longer located in the center of the object. As the cube rolls, the side with the greater mass is more likely to be at the bottom, since the object is more stable in that orientation.

Resources

Articles
Leopold, George. “Despite Its Struggles, Give Mir a Chance.” EETimes (September 15, 1997): Tech Web News. http://www.techweb.com/se/directlink.cgi?EET19970915S0054 This online article from EETimes (Electrical Engineering Times) gives the engineering perspective that, despite all of its difficulties, the technological wonders of Mir are not to be downplayed or forgotten.


Web Sites

NOVA Online—Terror in Space http://www.pbs.org/nova/mir/Delves deeper into the program’s content and themes, with features such as articles, time lines, interviews, interactive activities, resource links, program transcripts, and more.

Launch date: October 27, 1998.


Moscow, We Have a Problem http://www.pbs.org/newshour/bb/science/jan-june97/mir_6-25.html Transcript of a discussion from The NewsHour with Jim Lehrer (June 25, 1997) examining the future of joint missions between the United States and Russia in the wake of a crash between the Mir space station and a resupply ship. Includes an audio version of the segment.

Visibility Predictions for the Russian Space Station Mir http://www.skypub.com/mir/mir.shtml Locates Mir’s current position above Earth and provides predictions for where and when to look for Mir from your area.
NOVA reveals the secrets behind the on-screen images that have captured moviegoers' imaginations for years.

- The art of special effects relies on understanding perception—how the eye and brain perceive the world—and using that knowledge to make something look real when it isn’t.

- Special effects used in early movie making, including King Kong, Ben Hur and Gone with the Wind, are highlighted.

- The role that color, light, form, motion and depth play in perception—and how those can be manipulated to fool viewers—is explored.

- Some of the techniques used to film Titanic—including model making, computer animation and green screen technology—are described.

- Pyrotechnics experts—who blow up a building for The X-Files movie—use models, lighting and slow motion to achieve a realistic scene.

- The future challenge for computer special effects artists—how to make a computer-generated human being look completely real—is also explored.

To help them create Flubber, Industrial Light and Magic’s animators researched real-life products of varying viscosities.

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### Before Watching:

1. Have students think of and list the most enjoyable movies they have seen. Then have them list their favorite scenes from those movies. How do students think the scenes were made?

2. Lead a discussion about why special effects might be important in a movie (such as, used in a scene that would otherwise be too expensive, too dangerous, or take too much time to re-create, or in a scene that couldn’t be shot without special effects, or to create a place that was purely imaginary).

3. As students watch, have them take notes about how each special effect is accomplished, paying attention to two different kinds of techniques: mechanical (in which a trick is staged for the camera, like a person sitting in a car in front of a moving background image of street scenes), and visual (in which two or more elements are photographed separately and then combined, like an explosion of a model building that is later merged with a film clip of a cityscape).

### After Watching:

1. Discuss with students some of the techniques used to create special effects. What techniques, if any, surprised them and why? Have students revisit their movie list and reflect on what special effects might have been used to create their favorite scenes.

2. Work with an art teacher to introduce students to the elements of perspective drawing, such as shadow, light and vanishing point.
Objective
To investigate how geometry plays a role in perspective.

Materials for each group
- copies of the Putting It into Perspective activity sheet on page 23
- copy of the Distorted Room Template on page 24, enlarged to 200 percent
- construction paper or card stock
- scissors
- glue
- two same-size models (such as plastic toy figurines or photos of people from magazines) up to 1 1/2 inches tall (the taller the better)

Procedure
1. First stage a demonstration of perspective. Have two students the same height stand side by side near the end of a hall. Have one student begin taking steps backward until students begin to notice a difference in height between the two. From where they are, have the rest of the class measure the height of each student with a ruler or their fingers and observe other surrounding clues that suggest a difference in height: How much space is between the students' heads and the ceiling? Where is each student in relation to the end of the hall? How far did the students have to back up before a difference in height was noted? Discuss perspective with students. (You might want to replay the program segment of the two ships that deals with perspective.)

2. Organize students into groups. Either make a Distorted Room for each group or have students make one from the enlarged template and materials you provide for them.

3. After they have constructed their room, have students place two same-size models inside to explore perspective, using the questions on the activity sheet to guide their inquiry.

4. When students have finished, reconvene the class and discuss what they have learned, clearing up questions and inviting further investigation of perspective.

5. As an extension, have students build the room in different sizes and compare which size works best.
American psychologist Adelbert Ames created several famous optical illusions. One was a room that wasn't exactly what it seemed to be. But what was it? Do this activity and find out!

**Materials for your group**
- enlarged copy of the Distorted Room Template
- construction paper or card stock
- scissors
- glue
- two same-size models (such as plastic toy figurines or photos of people from magazines) up to 1 1/2 inches tall (the taller the better)

**Procedure**
1. Assemble your Distorted Room using the template provided.
2. Look at the room through the hole cut into the side.
3. Now place the models in the corners. Move them around and observe how they look placed together and apart in different parts of the room.

**Questions**
1. What does the room look like through the hole?
2. What happens to your models when you put them together in each of the two far corners? What happens when you place them apart in each far corner?
3. Why do you think the models look the way they do when placed apart in the far corners?
4. What is it about the room that makes the models look the way they do?
5. What kind of special effect might this technique be good for?
Distorted Room Template

Glue the template onto card stock. Cut out the room.
Fold up the walls, locking the tabs into the slots.
Cut out the hole in the wall opposite the angled wall.
Activity Answer

Perspective is the technique or process of representing on a plane or curved surface the spatial relation of objects as they might appear to the eye. Perspective didn't appear in art until the Italian Renaissance. Leonardo da Vinci (1452–1519) was the first to describe the principles of perspective in his notebooks. He treated perspective as a branch of geometry.

Students might observe that the room appears rectangular, but it isn't; that while the walls are straight, they don't all meet at 90° angles; and that when outside the room, the two models are the same height.

Resources

Books
Chronicles the use of special effects from the origin of motion pictures to 1984.

Provides an introduction to the world of illusion. Students discover how Steven Spielberg created the dinosaurs for Jurassic Park, how Jim Carrey's eyes popped out in Mask, and how the spectacular arrival of alien spaceships was staged in Independence Day.

Has recipes for students to create foods that aren't what they seem.

Web Sites
NOVA Online—Special Effects: Titanic and Beyond
http://www.pbs.org/nova/specialfx2/
Will include, among other features, an interactive exploration of how moviemakers create the illusion of making a miniature set look full-size, and interviews with computer graphics experts on how they got into the world of special effects.
Launch date: November 3, 1998.

The Animation Process
Pixar Animation Studios (creators of Toy Story) explains the process behind computer animation.

Visual Effects Reference Library
http://www.visualfx.com/library.htm
Includes references and links to visual effects magazines and online publications, and includes book references for visual effects, science fiction, cinematography/film, computer graphics, and animation.

Alt.movies.visual-effects
http://www.users.interport.net/~fletcher/fx-faq1.html
Newsgroup for discussion of movie and television effects. Current posts include technical questions about specific effects shots, industry-related news, requests for advice on how to shoot a sequence, and notices of upcoming live events, television specials and magazine articles relating to effects.
NOVA follows scientists’ efforts to predict the future of Mt. Vesuvius by monitoring current behavior and reconstructing past eruptions.

- Scientists monitor temperature changes, volcanic gases, seismic activity, and apparent “ground uplifts” in the volcano and nearby fields to detect warning signs of a coming eruption.
- Archaeologists and geologists investigate the A.D. 79 eruption that devastated Pompeii. By comparing an eyewitness account—known as the Pliny letters—to the 1980 Mt. St. Helens eruption, examining remains of victims, and analyzing rock deposits, they conclude that the A.D. 79 eruption was most likely an explosive eruption rather than a quiet outflow.
- Scientists combine data to create a computer animation of the A.D. 79 eruption. Actual video footage captures the eruption of 1944.
- A team of geophysicists map the size, location, and condition of Mt. Vesuvius’s magma chamber. The data suggests that the medium-size chamber is blocked by a plug.

1. On a map of Italy, have students locate Mt. Vesuvius, Naples, and the ancient Roman cities of Pompeii and Herculaneum. Use the map's scale to determine the distance from Vesuvius to these cities. Ask students to explain why they think communities settle near active volcanoes. What are the hazards and benefits?

2. Review with students how a volcano differs from an earthquake. Have students explore the crust, mantle, and core layers of the earth and what each is made of.

3. Italy’s Ministry for Civil Protection is developing a massive emergency evacuation plan for the communities surrounding Mt. Vesuvius. Ask students to think about natural hazards faced by their community. What would they do to prepare for such an emergency? Every state has an Emergency Management Agency (EMA) that assists communities in developing plans for coping with natural hazards. Class members can select a natural hazard (such as a flood or hurricane) and, as a group, write to their state’s EMA to learn about local plans.
Objective
To collect data and create maps to observe the relationship among volcanoes, earthquakes and lithospheric plates.

Materials
• copies of map from the Where on Earth? activity sheet on page 28
• access to resources from the Internet or school library
• 3 overhead transparencies
• overhead projector

Procedure
1. Organize students into three groups and distribute a map to each group. Assign each team to research and plot one of the following: 20 recent volcanoes, 20 recent earthquakes or the boundaries of Earth's major lithospheric plates. If students are having trouble finding information, direct them to the Web sites listed in Resources on page 29. If students are using books for their research, they can plot major or famous volcanoes and earthquakes instead of recent ones. Make sure groups use different symbols for volcanoes and earthquakes so that they can be distinguished on the overhead projection.

2. After the groups plot their data, photocopy each of the three maps onto an overhead transparency. First project the volcano and earthquake maps one on top of the other. Ask students to describe any patterns they observe. Then lay the plate boundaries map on top of the other two maps. Ask students to compare the locations of volcanoes and earthquakes with the locations of the plate boundaries and describe any patterns they observe. Finally, ask students to explain the apparent relationship between the location of the plates and the occurrence of volcanoes and earthquakes in those regions.

The activity found on page 28 aligns with the following National Science Education Standards.

Grades 5–8

Science
Standard D: Earth and Space Science

Structure of the earth system
• The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.
• Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions and mountain building, result from these plate motions.
• Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption and deposition of sediment, while destructive forces include weathering and erosion.

Earth's history
• The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past.

Grades 9–12

Science
Standard D: Earth and Space Science

Energy in the earth system
• The outward transfer of earth's internal heat drives convection circulation in the mantle that propels the plates comprising earth's surface across the face of the globe.

The origin and evolution of the earth system
• Interactions among the solid earth, the oceans, the atmosphere and organisms have resulted in the ongoing evolution of the earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.
Mt. Vesuvius is just one of many active volcanoes in the world. Where are other active volcanoes found? And how do the locations of these volcanoes relate to the locations of earthquakes and lithospheric plate boundaries? Find out by plotting and comparing these sites for yourself.
Volcanoes and earthquakes are not randomly distributed around the globe. Instead they tend to occur along limited zones or belts. With the understanding of plate tectonics, scientists recognized that these belts occur along plate boundaries. According to the theory of plate tectonics, the Earth's outer shell (lithosphere) is made up of seven large and many smaller moving plates. As the plates move, their boundaries collide, spread apart or slide past one another, resulting in geological processes such as earthquakes, volcanoes and mountain making. You might want to point out that not all volcanoes occur at plate boundaries. Some occur in the middle of plates in areas known as "hot spots." The Hawaiian Islands are an example of this type of volcano.

When comparing their maps, students will notice that volcanoes and earthquakes frequently occur at plate boundaries. Students who are familiar with the theory of plate tectonics might be able to explain the pattern or relationship they observe. Other students can conduct additional research to find information to help them explain their observations.

Resources

Articles
Describes volcanoes, floods, earthquakes, tornadoes, hurricanes and wildfires from the perspective of people who cope with them. Insert displays a distribution map of the natural hazards of North America.

Web Sites
NOVA Online—Deadly Shadow of Vesuvius
http://www.pbs.org/vesuvius/
Will include, among other features, an examination of the United States Geological Survey (USGS) Rapid Response Team, which waits in readiness to fly anywhere in the world at a moment's notice to monitor potentially dangerous active volcanoes. Launch date: November 10, 1998.

USGS Earthquake Information
http://quake.wr.usgs.gov/
Sponsored by the USGS, this site itemizes earthquake activity worldwide, including date, time, location, depth and magnitude.

Volcano World:
Current Volcano Activity
http://volcano.und.nodak.edu/vwdocs/current_volcs/current.html
Includes a map and list of the world's most recent volcanic eruptions.
Frozen in Heaven

Note: This program contains information about child sacrifice. You should preview the program to determine its appropriateness for your classroom.

NOVA accompanies anthropologist Johan Reinhard as he journeys to the 5,639-meter (18,500-foot) peak of Sara Sara in southern Peru in search of evidence of capa cocha, a ritual in which the Incas were said to sacrifice their own children to the gods.

- The program describes Spanish chronicles that detail Inca life and beliefs.
- Archaeologists ascend the mountain in search of evidence of the chronicled, but never proven, ritual. Observations of several bodies discovered earlier support the ritual’s existence, including a boy found frozen in the Chilean mountains, a girl found frozen on Mt. Ampato in Peru, and a boy found on Mt. Aconcagua in Argentina.

After Watching

1. Have students discuss the rituals they recorded. Why might those rituals have been performed? How might they be similar to or different from rituals performed today?
Siberian Ice Maiden

NOVA follows archaeologist Natalya Polosmok as she journeys to the Altay Mountains in southern Siberia to search for traces of an ancient people known as the Pazyryk.

- Polosmok and her team discover and unearth a wooden tomb surrounded by the frozen remains of six horses, uncovering a 2,400-year-old woman dubbed the Siberian Ice Maiden.
- The Ice Maiden is buried alone, lying as if asleep, in a wooden coffin with a headdress and a mirror. An afterlife meal, a yak horn vessel and a wooden table are also found outside the coffin. Archaeologists record the Ice Maiden's height, and discover a hole in her skull and peat packed in her body.
- They use radiocarbon dating, tree-ring chronology and biological testing to determine the age of the remains and time of death.
- The body is excavated and taken to Moscow for preservation and facial reconstruction. Another mummy, and other skeletons, are discovered elsewhere.
- The program concludes by raising the question of who has rights to the ancient graves.

Before Watching

1. To set the stage, ask students to locate the Altay Mountains on a map and to calculate the approximate year the Ice Maiden died (about 2,400 years ago, or around 400 B.C.).

2. Archaeologists can infer much about a culture and its beliefs from their findings. As students watch, have them make a chart and record archaeologists' findings, inferences, and any support that exists for each, such as ancient writings or scientific tests.

After Watching

1. Archaeologists draw conclusions from as many pieces of evidence as they can find. Discuss and compare student charts that list what archaeologists found and whether students think the inferences archaeologists made are valid and why.

2. Have students consider the benefits and costs of excavating a burial site and state whether they believe archaeologists should unearth these sites and why.
Return of the Iceman

NOVA examines how science is unlocking the secrets of the Iceman, a man discovered in 1991 frozen in the Italian Alps.

- Found with the Iceman are a copper axe, leather clothes, flint tools, shoes lined with grass, and a quiver full of arrows.
- Mapping of the site shows that the body—thought to have been discovered in Austria—was actually found 92 meters (100 yards) inside the Italian border.

Found within Italy's borders, the Iceman is carefully removed from the earth to be sent elsewhere for further study.

- A battery of tests—including carbon dating, microscopic analysis, X-rays and endoscopy—reveal that the Iceman:
  - had been frozen for about 5,300 years, making him the oldest frozen mummy ever found;
  - had heavily worn joints;
  - was about 45 years old;
  - ate a last meal of meat and rough milled wheat; and
  - had traces of copper on the surface of his hair and arsenic inside, indicating that he might have been involved in smelting.
- Reconstructive archaeology demonstrates how the Iceman might have built and used his copper axe.

Before Watching

1. This program features a number of archaeologists who study the Iceman. But what exactly do archaeologists do? How does an archaeologist differ from a paleontologist? (Archaeologists study evidence of past human cultures, while paleontologists study life that existed in prehistoric times.) What other scientists are involved in studying ancient civilizations, and what do they do?

2. Archaeologists inferred a lot about the Iceman's lifestyle from observations they made and tests they performed. As students watch, have them create a chart and take notes about each observation or test, what data resulted from the observations or tests, and what was inferred from the data about the Iceman.

After Watching

1. Guide a discussion about what was learned about the Iceman, listing students' notes on the board and clearing up any inconsistencies. What do students think about the conclusions that archaeologists drew? What other conclusions might have been reached?

2. This program provided some evidence that the Copper Age should be redated to an earlier time in this region of Europe. Have students research the Stone Age and the Copper Age and the transition between them. What were the defining characteristics of each age? What were some characteristics shared by both ages?
Medical Imaging Tools

Radiography (X-rays), computerized axial tomography (CAT) and magnetic resonance imaging (MRI) allow researchers to study a body without invading or destroying it. How do each of these tools work? What were researchers able to find out with the use of each new technology?

CAT scans use X-rays to capture cross-section images of the body, which are then analyzed by computer and formed into a three-dimensional image.

X-rays are good for imaging hard, dense substances, like bone.

MRIs provide information about soft tissue that contains water.
Objective
To investigate the rate of microbial growth at different temperatures.

Materials for each group
- copies of the This Is Rotten activity sheet on page 35
- 3 small Petri dishes
- 1 small packet unflavored gelatin
- small saucepan
- 1/2 cup water
- 2 teaspoons sugar
- tape
- one food sample (such as tofu/bean curd, strawberries, or bread)
- knife for slicing
- refrigerator and freezer

Procedure
1. Organize students into groups and distribute materials and activity sheets. With students, determine what food they would like to use in the experiment, and assign each group one sample to study (samples might include tofu/bean curd, strawberries or bread). Also discuss how students will quantify and measure microbial growth rates.

2. Have students predict what will happen to their sample at various temperatures. Then have them prepare the medium that will contain their samples. Important: Discuss with students that their medium may not be completely sterile and that what grows in it might not be directly related to their samples. (As an extension, you may have students repeat the experiment using sterile techniques and compare the results with the first experiment.)

3. The containers should be left in a dark place at room temperature. Once microorganisms have begun to grow, have students record the temperature for the refrigerator, freezer, and cupboard or drawer, and then place one of their samples in each environment.

4. Have students check their samples every few days for two weeks and record their observations.

5. To conclude, ask students to describe the differences in the rate of microbial growth among the samples in the different environments, and possible reasons for those differences. Then discuss with students what might be responsible for promoting or inhibiting growth in each specimen.

6. As an extension, students could examine their final products unaided, with a hand-held magnifying glass, and then with a 10x (or stronger) microscope and describe what they see.

The activity found on page 35 aligns with the following National Science Education Standards.

Grades 5–8
Science Standard C: Life Science

Populations and ecosystems
- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

Grades 9–12
Science Standard C: Life Science

Matter, energy and organization in living systems
- The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.
This Is **Rotten**

When an organism dies, it begins to be broken down by lots of microorganisms like bacteria and mold. But what happens to the organism at different temperatures? Do this experiment with your own samples and find out!

**Materials for your group**
- 3 small Petri dishes
- 1 small packet unflavored gelatin
- small saucepan
- 1/2 cup water
- 2 teaspoons sugar
- tape
- your food sample
- knife for slicing
- refrigerator and freezer

**Procedure**

1. On a separate sheet of paper, predict what you think will happen to your food sample in each environment.
2. Boil 1/2 cup of water. Remove from heat. Add 2 teaspoons of gelatin and 2 teaspoons of sugar. Stir until dissolved. Let the solution cool for 10 minutes. Fill the bottom of each Petri dish about halfway. Put the lids on and let stand overnight. This is your medium to support microbial growth.
3. Collect your assigned food sample, slice into thirds, and place one slice in each Petri dish.
4. Tape, but don't seal, the Petri dishes closed (see illustration). Label each dish with the contents and date.
5. Place the dishes in a dark place, such as a cupboard or drawer.
6. Check the samples daily. Make a chart and record daily progress of the microbial growth. Describe color, size, and fuzziness, as well as anything else you see. (Make sure to not touch the samples.) You may want to draw what you see as well.
7. Once you have obtained a quantity of microorganisms growing, record the temperature of the three locations (refrigerator, freezer, and cupboard or drawer) and place one sample in each.
8. Check the samples every few days. Record your observations in your chart. Make sure you don't open your Petri dish once something has started to grow.
9. After two weeks, make your final observations and describe what you see.

**Questions**

Write your answers on a separate sheet of paper.

1. Which sample showed the most microbial growth? Which showed the least? Why?
2. Did the samples in each environment grow at the same rate or at different rates? Why?
3. What else could you do with the samples to promote microbial growth? What could you do to limit growth?
4. How might an archaeological find, such as a body, be affected by the temperature of the environment in which it is found?
Objective
To analyze and interpret information in order to locate an archaeological site.

Materials for each group
• copies of the I Can Dig It! student activity sheet on page 37

Procedure
1. Organize students into groups and distribute the activity sheets. Have students read the scenario in the Field Journal Notes. Discuss the nature of the clues given and how students might use them in their search. (You may also want to invent your own scenario from a time period or culture you have previously studied.)

2. Have groups research the scenario. You may want to provide hints to students having difficulty solving the mystery. (For example, “You are looking for a northern culture,” or “The burial site is located in a chain of volcanic islands.”) Once students have completed the activity, have them present their findings to the class and explain how they arrived at their conclusions.

3. As an extension, consider having students create their own archaeological field journals. In groups, have students create a description of a burial or dig site, including information about items found, climatic conditions and other clues of their choice. Then have groups exchange clues and try to identify each other’s culture and locale.

We came upon a cave. As we groped around in the dark, we found a large leather bundle hanging from the ceiling. Our flashlights revealed several similar bundles hanging, and about us many lying on platforms on the floor.

We opened one leather package to discover a curled-up body. We identified the body as a male and the organs had been removed and the cavity filled with dry grass. The body had mummified and skin had been removed. We found a wooden canoe, a woven basket, and containers made of whalebone.

We also found a large leather bundle wrapped in waterproof leather. We found 50 water bottles, all of which had received cold water.

The activity found on page 37 aligns with the following National Science Education Standards.

Grades 5—8
Science
Standard G: History and Nature of Science

Science as a human endeavor
• Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity—as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas.

Grades 9—12
Science
Standard G: History and Nature of Science

Science as a human endeavor
• Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem.
You have discovered a journal in your grandmother's attic. The journal is filled with field notes describing the discovery of a fascinating burial site—but the notes do not identify whose burial site it is or where it is located. Your mission is to find out. Use the clues within the notes to guide your search. Good hunting!

**Procedure**

1. To help you visualize the scene, you might want to make a drawing of the cave based on the description.
2. Then use reference books and any other sources you would like to solve the mystery of what culture this is and where it is located.

**Questions**

Write your answers on a separate sheet of paper.

1. What culture is this?
2. Where is the burial site located?

We came upon a cave. As we groped around in the dark, we found a large leather bundle hanging from the ceiling. Our flashlights exposed several similar bundles hanging, and about as many lying on platforms on the floor.

We opened one leather package to discover a curled-up, dried-out body. We visually examined the body. It was a male and its organs had been removed and the cavity filled with dry grass. The body has muscle and skin, but there is no evidence of fat. It had been tied in a squatting position and dried out. It was wrapped in woven clothing and waterproof leather. We found 50 such bodies, all of which had received similar treatment. The skeletal remains showed no signs of trauma.

As we looked around we also found woven baskets, furs, a wooden canoe, and containers made of whalebone.

Think about the clues that might be illustrated here.
Activity 1 Answer

This Is Rotten
Microbial growth will continue to flourish at room temperature, will be slower in the refrigerator, and will be slowed to the extent that growth may not be visible within the given time in the freezer. The microorganisms that have grown in each sample will probably include bacteria, which are single-celled organisms that feed on waste materials and dead organisms. Mold may also be evident.

Activity 2 Answer

I Can Dig It!
The scene depicted is based on an actual Aleut burial site located on the Aleutian Islands off the coast of Alaska. The additional artifacts and cave drawings were added as clues to help students identify the site’s culture and location. The Aleutian mummies were hung from the ceiling or set on platforms in this Alaskan cave nearly 260 years ago. These bodies were mummified just before 1740.

The clues can be used in a variety of ways to solve the mystery of whose burial site this is. For example, the presence of furs, whalebone and a canoe suggest that the culture is from a northern location near water, which may lead students to investigate Alaska, Russia, Greenland, Iceland and Norway. Depictions of sheep, moose and caribou on the cave walls help students pinpoint Alaska as the region in which this culture resides. Cave drawings depicting a chain of islands surrounded by water pinpoint Alaska as the land mass. If students then research where volcanoes are found in Alaska, they will discover that almost all of Alaska’s active volcanoes are in the Aleutian arc. This should lead them to seek out information about the Aleuts, which will reveal that the burial site is theirs. (Students who choose to use volcanoes alone to as a method to pinpoint the location will find that a number of volcanoes exist in Alaska, Russia and Iceland.)
Resources

Books
Provides an introduction to Ice Age people. Text and images depict artifacts and cave paintings left behind by ancestors of modern humans.

Provides the prehistory of the Andean region, including a thorough summary of Inca civilization.

Articles
Describes the December 1997 return of Reinhard and his crew of archaeologists to the summit of Pichu Pichu in the Peruvian Andes to discover more human ritual remains, gold figurines and other evidence of the Inca heritage.

Web Sites
NOVA Online—Ice Mummies
http://www.pbs.org/icemummies/
This Web site, originally a NOVA/PBS Online Adventure launched in Fall 1996, will provide updated information about the archaeological expeditions that discovered three different ice mummies. 
Launch date: November 24, 1998.

Mummies 101
http://www.pbs.org/nova/chinamum/mummies101.html
Contains information about mummification, specifically the practices of the Aleut. Note: This site contains some graphic photos. Preview first to determine its appropriateness for your students.

Ice Treasures of the Inca
Contains extensive information on the Inca ice mummies.

The Incas
http://vif27.icair.iac.org.nz/People/Inca.htm
Provides information on the Inca religion, culture, agriculture and roads, as well as background on the Spanish Conquest and the Cuzco and Machu Picchu archaeological sites.

Archaeology
http://www.archaeology.org/
Archaeology is an online and print publication of the Archaeological Institute of America. The site includes articles about current archaeological topics and a news brief about the Iceman's return to Italy.
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Cracking the Ice Age
Could the Himalayas be the cause of one of the planet's most dramatic climactic changes—the ice age? Take a trek to Tibet with a renegade band of researchers bent on proving this controversial concept. Educational Use Only. 1 hr. WG2320* $19.95 $9.95

Deadly Shadow of Vesuvius
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NEW Mysterious Mummies of China
Perfectly preserved 3000-year-old mummies have been unearthed in a remote Chinese desert, but they have long, blonde hair and blue eyes. New evidence of the lost civilization of the Tocharians along the Silk Road offers more clues to this mystery from the past. 1 hr. WG2202 $10.06 $9.95

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Archaeologists are now revealing that Columbus, the Vikings reached America. Vikings in America

Culture and Exploration, continued

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Inca
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Mind of a Serial Killer
Follow the FBI's psychological detectives as they race against time to penetrate the mind of a serial killer—and stop him from striking again.
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Hunt for the Serial Arsonist
Trail along with fire sleuths as they discover the mysterious source of a series of L.A. store fires, and capture a surprising suspect filmed by NOVA. 1 hr. WGA2214 $49.95

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Learn the secrets of counterfeiting—made easier by today's technology—and find out what the Feds are doing to fight back: a new look for US currency, with layers of security made easier by today's technology.

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